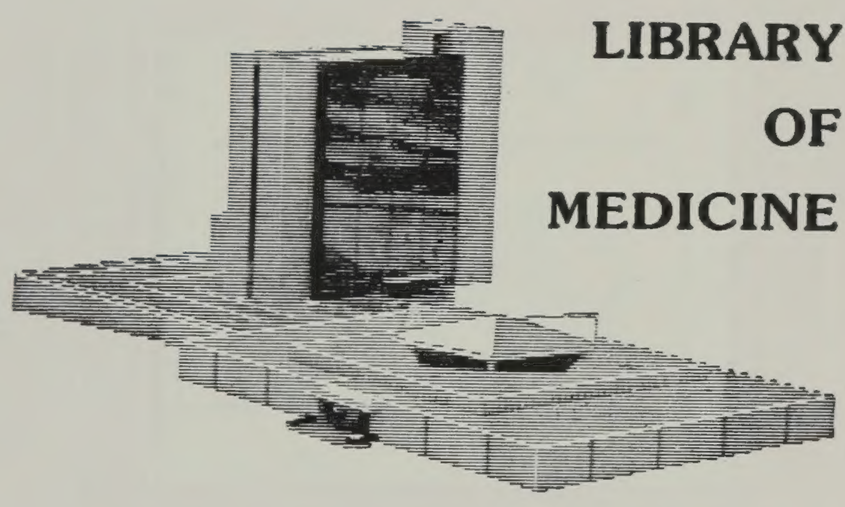
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CONTRIBUTIONS

TO

OPERATIVE SURGERY

265

AND

SURGICAL PATHOLOGY.

BY

J. M. CARNOCHAN, M.D.,

FORMERLY PROFESSOR OF SURGERY IN THE NEW YORK MEDICAL COLLEGE, SURGEON-IN-CHIEF TO THE STATE EMIGRANTS' HOSPITAL, 1850-71, &c.

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DEDICATION.

TO

SAMUEL D. GROSS, M.D., D.C.L. (OXON.),

PROFESSOR OF SURGERY IN JEFFERSON MEDICAL COLLEGE, PHILADELPHIA,

WHOSE INTELLECT, DURING A LONG AND ILLUSTRIOUS CAREER,

HAS BEEN DEVOTED TO THE

SUCCESSFUL CULTIVATION AND ELUCIDATION OF THE SCIENCE AND ART OF SURGERY,

AS SURGEON AND AUTHOR,

THIS WORK IS

RESPECTFULLY DEDICATED,

AS A TRIBUTE TO HIS HIGH PROFESSIONAL ATTAINMENTS AND EMINENT PRIVATE VIRTUES,

BY

THE AUTHOR.

EPISTLE.

TO VALENTINE MOTT, M.D., LL.D.:

My dear Sir,—

A witness, from early youth, of your efforts for the advancement of our Art, I naturally attach a high value to your opinion upon surgical subjects. Permit me, therefore, to ask your perusal of these contributions, and, at the same time, to express my acknowledgment that whatever merit they may display is to be attributed, in a measure, to your example.

Richly endowed by nature, your genius acquired its fine proportions under the tuition of Astley Cooper, the disciple of Hunter, whose methods and principles you were thus enabled to inaugurate successfully in the schools of your native land. With this signal service to science, as well as with several great and original improvements in Operative Surgery, your name will ever remain associated; and, for my part, I regard it with the veneration which becomes a pupil who is sensible of the beneficial influence you have exercised over his surgical career.

Animated by this sentiment, I beg leave to subscribe myself,

Your most obedient servant,

J. M. Carnochan.

PREFACE.

Since the time that Laënnec applied the stethoscope to the exploration of diseases of the chest, as an important addition to the physical means of diagnosticating pathological conditions of the lungs, other organs have been subjected to direct examination, upon a similar principle, and through the medium of the senses, by the use of various instruments invented for the purpose. Percussion has been brought into use to reveal the measure of dulness or clearness of sound. The deepest part of the globe of the eye is made plain to the observer, and the intricate mechanism and conditions of the ear are more perfectly explored. The nares, pharynx, larynx, rectum, urethra and bladder, vagina and uterus, can now be minutely inspected. Where the sight, the touch, or the sound cannot reach, physiological discoveries have shown the way to localize in such organs as the brain and spinal marrow the seat of morbid phenomena and changes which were previously occult and not comprehended. The temperature of the body and the oscillations of the pulse have been measured by ingenious instruments, but these will scarcely ever supersede the information acquired by the trained touch and the mental record impressed upon the senses by observation and experience.

In 1801 Bichat gave a fresh impulse to the study of medicine by publishing his great work on general anatomy, supplying a more correct knowledge of the tissues of which the human body is composed. In this important work he was followed by Béclard, who contributed to the labors of his famous contemporary. Their efforts were the basis of farther improvements. Analytical chemistry and the microscope were applied to make known the more minute structure and composition of the healthy and morbid conditions of the solids and fluids. Thus the knowledge of medicine has been extended, the sources and nature of disease are more readily and

precisely determined, and the removal of obscurity has been followed by accuracy of diagnosis and a more rational system of therapeutics.

Following the example of my early master, Professor Syme, of Edinburgh, I publish these contributions in the hope that they will be found useful by those who recognize that it is from the study of particular facts operative surgery frequently derives its most valuable suggestions. Operative surgery embraces not only a knowledge of the pathological condition indicating the necessity for an operation, but the management of the patient immediately previous to its performance, a comprehension of the contingencies that may arise during the operation, and the proper treatment of the case afterward.

The life of man is too short to allow him, even with the greatest industry, to witness all the varieties of accident or disease; and as there is no limit to the multiplicity of pathological differences, the most experienced practitioner may find himself in the presence of unknown and unforeseen conditions. Hence it is incumbent on the surgeon to read much, as well as to see much, and to extend his knowledge as far as possible beyond the sphere of his own immediate observation. This is especially the duty of country practitioners and of practitioners in small towns and villages; and even in the case of surgeons dwelling in the midst of large centres of population, with corresponding hospital facilities, it will not do to neglect the experience of other men, under the penalty of abdicating progress in both the science and art of surgery. The practitioner may be deficient, without blame, in some of the natural endowments which go to make the complete surgeon: he may be wanting in tact, in presence of mind, in clearness of vision, in manual dexterity or bodily strength; but a conscientious man will never be able to justify to himself an incapacity which proceeds from ignorance of the recorded triumphs of operative surgery in difficult cases. These are not always described at length in the text-books, and, in fact, can only be known through the current surgical literature of the day. The science of operative surgery exhibits results in a harmonious and systematic shape; but these results are precisely the particular facts by whose assistance science is advanced, the elements without which science could not exist at all. The methodical treatise, or *corpus scientiæ*, is indispensable to the professor, the practitioner, and the student; but, after all, it must be recollected that the progress of operative surgery is chiefly effected by the discoveries of great surgeons in particular cases, and by new methods which effect cures

that were once deemed beyond the reach of art. Thus the treatment of aneurism by the method of Hunter was a progress in operative surgery, for it enabled the surgeon to effect the cure of aneurism in cases which had always before been regarded as hopeless.

In some of the cases contained in these contributions the methods are essentially curative—as in the exsection of the entire ulna and in the exsection of the entire radius, where the amputation of the entire member is avoided; in others the methods are purely operative; but whether curative or operative, I flatter myself that they are entitled to consideration, in many instances, on the ground of originality of conception. And I may add here that while respect for life will dictate to the surgeon the greatest prudence—will counsel him to attempt no operation which he would not be willing to perform on his own child—it will also teach him that if the extremes of boldness are to be shunned, pusillanimity is not the necessary alternative. The surgeon who has not sufficient courage to propose a useful operation, and sufficient skill to perform it, is as open to censure as the reckless practitioner who is swayed by the unworthy lure of notoriety.

While recognizing the value of the recent improvements and innovations in medicine and surgery, it is not necessary to parcel out and subdivide a great art to an unlimited extent. The invention of an instrument or any improvement, with the view of detecting with greater precision the characteristics of a particular class of diseases, does not form a sufficient basis for magnifying the pathological phenomena of every organ into a distinct department of science. Such a custom, too prevalent at present, tends to give undue importance to manual and instrumental efforts, to the neglect of therapeutic and conservative measures, thus leading to errors of judgment, and to a course of practice often useless and injurious. The principles and doctrines inculcated by the great masters—by Harvey, Hunter, Boyer, Desault, Larrey, Dupuytren, Lisfranc, Roux, Dieffenbach, Astley Cooper, Charles Bell, Brodie, M'Dowell, Physick, Valentine Mott, and other illustrious men of preceding times—must be taken as the foundation upon which has been erected the superstructure of modern surgery.

This work was commenced some years since, and had reached the fourth number, but was interrupted by the destruction by fire of the establishment of the printer, thereby losing plates, drawings, lithographs, etc. The epistle addressed to Valentine Mott, following the title-page and dedication, was printed while he was living, and is

now inserted unchanged, from sentiments of great regard for his memory. Some of the matter has been previously published in various medical journals, but has been thought of sufficient importance to be reproduced, as presenting special types of disease, and the character of the work enables me to add whatever fresh material I have since collected or may collect.

I have placed as introductory to the following pages an address on the study of science, given before my class when Professor of Surgery in the New York Medical College, which, although it was delivered some time since, may not be out of place as touching on the inductive method of research now so much in vogue among the scientists of the present day.

J. M. Carnochan.

New York, 14 East Sixteenth Street, *November*, 1876.

INTRODUCTORY ADDRESS

ON THE

STUDY OF SCIENCE.

"What gave Marcellus the greatest concern," relates Plutarch, in his account of the storming of Syracuse, "was the unhappy fate of Archimedes, who was at that time in his museum, with his mind as well as his eyes so fixed and intent upon some geometrical figures, that he neither heard the noise of the Romans, nor perceived the city to be taken. In this depth of study and contemplation, a soldier came suddenly upon him, and commanded him to follow him to Marcellus; which he refusing to do until he had finished his problem, the soldier in a rage drew his sword and ran him through." The studies, gentlemen, which enrapt the soul of Archimedes in the midst of war's alarms must have been a source of pleasure, pure and high, not less valued than existence itself. With such men, the appetite for finding out laws from facts, causes from effects, necessary truths from the floating occurrences of the day, puts in its claim to gratification, which is as legitimate as that of the animal nature for food and sleep. If the question, "What fruit does science bring?" be understood, as it certainly ought not, to refer to the *material* wants of humanity, it is a base and sordid question, against which every better mind indignantly protests. Science was never brought to its present height by hopes of wealth, plenty, and comfort alone, but chiefly by those "admirable loves" with which she can inspire her followers. But whilst the coldest utilitarians admit that the value of science must not be estimated by what she can practically perform, no doubt it must be granted that even the highest sciences do condescend to help our lowest wants. Astronomy, Chemistry, Geology, and Mechanics, not only furnish delightful contemplations to the student, but they put food into the mouths of the million: they clothe them, and fill their purses: they put houses over their heads, and adorn them with objects of beauty and convenience. The acquisition of knowledge is, indeed, in itself a positive good: the man who has his mind open to the perception of surrounding objects, and is led to reflect upon their nature and properties, has much greater capabilities of happiness—has much greater capacity for understanding and fulfilling the duties of his station, than if

brought up in gross ignorance, without ever having exercised his intellectual powers. Besides attaining the self-denying, upright, benevolently co-operating, and industrious habits which live in the very atmosphere of science, an enlightened intellect looks after and before, observes relations, calculates consequences, and, according to the nature of things, avoids evil and secures good. There is no situation in life that must not, after all, owe its highest enjoyments to feelings with which the mind is connected: there is none which may not be cheered and refined from the same source. Independently of all worldly considerations, scientific pursuits always bestow rich rewards on their votary, in the delights attendant upon their cultivation, and the temporary oblivion, at least, of all care, in the abstraction they require. Finally, it may be said that while we have long experienced that knowledge is profitable, we are now beginning to find out that it is moral, and shall at last discover it to be religious. Aristotle declared the highest and truest science to be that which was most disinterested. Bacon, treating science as separate from religion, asserted knowledge to be power, and held that truth must be tested by its fruits, that is, its instrumentality in promoting the right and useful. Both assertions may be justified and reconciled by the fact that, while no real knowledge is powerless and fruitless, the fruits differ in refinement and value; the highest being, unquestionably, those disinterested gratifications which minister to the highest wants and the highest faculties, and which earned for Philosophy the title of a "divine love," realizing the mysterious longing of the soul, and promoting the accomplishment of its destiny: "To rise in science as in bliss."

But science confers these advantages only on condition that those who cultivate it shall be absolutely devoted to truth, and that far from seeking to maintain the error they may have mistaken for it, they shall be the first to renounce it, and incline their heads to those who set them back in the right path. But is the acquisition of truth as easy as is commonly supposed? This question must be answered unhesitatingly in the negative. It will not suffice to declare that we are seekers after truth; we must be also able to say that we know how to distinguish it from error, and that being able to demonstrate its reality, we are likewise able to develop its consequences. The hostility which well-intentioned men sometimes bear to the propagation of truth proceeds, in part, from a secret dread that one day all things may be explained—thus evincing the profoundest of all infidelity, the fear lest the truth be bad—and, in part, from the belief that it is frequently the cause of those disturbances which threaten the existence of the social state. But truth should not be held responsible for the results of error. It is demonstrable that the evil effects we so frequently witness proceed from erroneous opinions propagated as truths, and which would have been nipped in the bud had they been submitted to a method of examination fitted to establish their falsehood; the greatest of all falsehoods being the

pretension to understand and explain that which it is impossible for any human being to understand and explain. Thus the ability of discriminating between what is true and what is false lies at the very threshold of the pursuit of science; and we acquire this ability by familiarizing the mind with the rules which constitute method. There exists a general method, and there also exist particular methods, adapted to the different branches of human science. The rules of the general method are found in all the particular methods; but every particular method has special rules, which constitute the philosophy of the science to which they belong. To these special rules we are indebted, from Galileo down to the present time, for the immense progress we have made in the natural sciences. In Astronomy, for instance, we take for our point of departure the observation of phenomena, and seek for their causes conformably to inductive rules which are appropriate to that science. The advantages of this direction of the human mind are no longer contested. We proceed from acquired truths to truths that are still latent, or, in other words, from the known to the unknown, and thus the progress of knowledge is definitively assured.

But truth, the *magnum opus* of science—its possible achievement—the aim and object of the labors in which you are about to engage in these academic halls—where and how is it to be found? This inquiry leads us directly to the consideration of the distinction of truths *a priori* and truths *a posteriori*, and of the methods which derive from them.

If there are any truths which the mind originally possesses, whether consciously or unconsciously, they may be called *a priori* truths, as belonging to it prior to all that it acquires from the world around. On the other hand, truths which are acquired from observation and experience are called *a posteriori* truths; because they come to the mind after it has become acquainted with external facts. How far *a priori* truths are possible, is the great battle-field of mental philosophy; but no one at present maintains that the mind can know any thing at a point of time before its observation of external things began. However independent of experience any process may appear to be now, as, for instance, that by which geometrical truths are proved, we may be sure that we made much use of observation before we educed the very laws which place it in our minds far above all need of confirmatory evidence from observation. A mind which never observed would not be mind. But the question is, whether even the facts which we observe do not furnish evidence that something was in the mind before it was directed to the facts; just as we know by looking at something that we have eyes, and must have had them before we looked; although, without putting them to their common use, we could never have known that we had them at all. Now, without going into the dispute how much of our knowledge is *a priori*, we may be able to show that at least the conditions of all our knowledge are so—that the mind does not simply reflect the images of things without, but impresses

characters of her own upon them—that our knowledge of things is not the exact counterpart of the things, but of the things and mind operating together. When we see our image in a mirror, we know that our shape is the cause of it on the one hand, and the power of reflection in the mirror on the other: if we were to see it multiplied, or increased, or diminished, or changed in hue, we should infer that the mirror had several angular faces, or was convex, or was concave, or made of tinted glass. Each of these properties would be inherent in the mirror *prior* to our presenting ourselves before it; they are its *a priori* laws, although we could only know them *a posteriori*, by a trial. When an image is received upon the mirror of the mind, we see that the latter, also, has its laws and properties. The mind does not simply receive the impressions of the senses; it groups them, judges about them, separates their qualities from each other, and draws inferences about the qualities which like objects, hitherto unknown, may be expected to have. But qualities, classes, inferences, are not objects of sense, however completely they may reside in or be drawn from these objects. They have no separate existence out of the mind; whilst, within it, they are perfectly distinct. This transmutation of objects of sense into their elements must, therefore, be the work of the mind alone. It is a law of the intellect itself, and never was or could have been in the sensuous impressions we have received. The acts of the mind are so quick, so numerous, so complex, that they are not easy to note and describe, although we daily perform them, and that without serious mistakes. As the act of standing erect, so simple apparently, calls into operation a numerous array of muscles by means of which the body perpetually sways and adjusts itself without conscious effort, so we may believe that the mind goes through acts which, from long practice, scarcely awaken her own attention, much less the sense of pain and effort, yet which involve a great number of subordinate acts, depending on distinct principles. When the English traveller, Sir Francis Bond Head, was journeying across the pampas of South America, his guide, one day, suddenly stopped him, and pointing high into the air, cried out: "A lion!" Surprised at such an exclamation, accompanied with such an act, the traveller turned up his eyes, and with difficulty perceived, at an immeasurable height, a flight of condors soaring in circles in a particular spot. Beneath that spot, far out of sight of himself or guide, lay the carcass of a horse, and over that carcass, as the guide well knew, stood a lion, which the condors were eying with envy from their airy height. The signal of the birds was to the guide what the sight of the lion, alone, would have been to the traveller—a full assurance of its existence. Here was an act of thought which cost the thinker no trouble, which was as easy to him as to cast his eyes upward. The sight of the condors convinced him that there was some carcass or other; but as they kept wheeling far above it, instead of swooping down to their feast, he guessed that some beast had anticipated them. Was it a dog or some other inferior animal? No.

The condors would not fear to drive such away, or share with it. It must be some large beast, and as lions abounded in the neighborhood, he concluded that one was there. These steps, at least, of thought, and probably many more, rushed through his mind, and were summed up in the words: "A lion!"

From the primary conditions of thought—*a priori* and *a posteriori* truths, or, in other words, mental action and experience—science is derived. In its most comprehensive sense, it is defined to be a system of principles and deductions to explain some object-matter. To fulfil its intention, every science must have attained to true statements concerning its object-matter, so far as the nature of the case and the present means of examination allow: it must be able to define the object-matter and its several subordinate parts with clearness and precision: it must be able to indicate the extent of the domain the object-matter covers; and, lastly, it must exhibit these results in a systematic and harmonious shape. For the first, it must employ Induction and Deudction: the second is the province of Definition: the third is provided for by Division; and the fourth may be referred to Plan.

The search after truth cannot long dispense with any one of these instruments; and even with the free use of them, the history of science shows how slow has been the advance, how largely the sand and mud of error have been mixed with the gold grains of truth. All of them, in their degree, have to do with evidence—with the proof of propositions: Induction and Deduction, chiefly with the discovery and appreciation of evidence; Definition, Division, and Plan, chiefly with the statement and arrangement of its results. Hence, if we have to answer the question whether a criterion of truth, that is to say, a standard for judging of the truth of propositions, is possible, the answer is, that evidence is the sole means of establishing, and therefore the sole standard for testing, the truth of any proposition, and that all the operations connected with evidence contribute their share to the criterion. In fact, no shorter rule, no more portable touchstone, can be indicated than the whole science and rules of evidence. And in the special cases where other criteria appear to be applied—as in the discussion whether religious truth is to be tried by external testimony or internal conviction, whether historical evidence or the religious sentiment is the best criterion—the dispute is only as to the kind of evidence that shall take precedence.

Induction is usually defined to be the process of drawing a general law from a sufficient number of particular cases: Deduction is the converse process of proving that some property belongs to a particular case, from the consideration that it comes under a general law. More concisely, Induction is the process of discovering laws from facts, and causes from effects; and Deduction that of deriving facts from laws, and effects from their causes. For instance, that all bodies tend to fall toward the earth is a truth which has been reached inductively, by considering a number of bodies where that tendency has been displayed: if from this general principle we

argue that the stone we throw from our hand will show the same tendency, we deduce. If it were always possible duly to examine the whole of the cases to which a law applies, and to see by intuition the significance of each, the process of Induction would be simple enough. But a complete inspection of all the cases is very seldom possible. Even the laws on whose invariable operation the strongest reliance is placed must have been laid down upon the evidence of a number of cases very limited, when compared with the whole: that men must all die, and that heavy bodies tend to fall toward the earth, are statements which no one can boast of having verified by enumeration. The perfect certainty with which they are believed rests upon far less than the millionth part of the cases that might be brought to bear witness about them. Nor, again, are the significant and essential circumstances easy to observe in the few cases that lie within the reach. Either they escape notice altogether, as did the fact of the earth's revolution in the early days of Astronomy, or they are so entangled or overlaid with a mass of other facts that their import does not at first appear; like the action of cold in the production of dew, or the influence of an open drain in producing and sustaining fever. It appears, then, that the argument by which a law is laid down as the exact sum of all the single cases will not suffice for scientific research. The statement, for instance, that all metals combine with oxygen could not be formed until people discovered, what at first no one suspected, that oxygen was the cause of the rusting and tarnishing of metals: but this is still open to dispute as an invariable truth; for a metal which refuses to combine with oxygen may hereafter be discovered. Science, therefore, must employ other instruments beside this argument, so very limited in its application, so very liable to question.

In the first place it may be asked: How are the causes of facts to be distinguished among a multitude of other causes, all open to observation? To this the answer is: By the principle of generalization. All men are apt to notice likenesses in the facts that come before them, and to group similar facts together. The similarities are sometimes so obvious that the most careless observer is arrested by them. The rise of the tide to-day and yesterday, the tendency to fall which a stone from the hand, an acorn from an oak, and a hailstone from a cloud, alike exhibit, and the power of growth exhibited by a grain of corn, afford groups of cases which seem so to classify themselves as to leave the mind little room for inquiry. The faculty by which such similarities are apprehended is called Observation: the act of grouping them together under a general statement, as when we say, "all seeds grow," "all bodies fall," is Generalization; and from this principle follow some practical rules for ascertaining causes; such as:

The cause of a given effect *may be* the same as we know to produce a similar effect in another case better known to us.

For example, Berzelius records that a small bubble of the gas called seleniuretted hydrogen, inspired by accident through the nose, deprived him for some time of the sense of smell, and left a severe catarrh which lasted for fifteen days. An English etiologist suggests that the corresponding effects of influenza may be traceable to the same cause as undoubtedly produced them here—to the admixture, namely, of this or some similar substance with the air we breathe; and as a suggestion, this is perfectly legitimate, and may prove highly valuable.

Another rule is: If we can either find produced by nature, or produce designedly for ourselves, two instances which agree *exactly* in all but one particular, and differ in that one, its influence in producing the phenomenon, if it have any, *must* thereby be rendered sensible.

If that particular be present in one instance and wanting altogether in the other, the production or non-production of the phenomenon will decide whether it be or be not the only cause; still more evidently, if it be present *contrariwise* in the two cases, and the effect be thereby reversed. But if its total presence or absence only produces a change in the *degree* or intensity of the phenomenon, we can then only conclude that it acts as a concurrent cause or condition, with some other, to be sought elsewhere. In nature, it is comparatively rare to find instances pointedly differing in one circumstance, and agreeing in every other; but whenever we call experiment to our aid, it is easy to produce them; and this is, in fact, the grand application of *experiments of inquiry* in physical researches. They become more valuable and their results clearer in proportion as they possess this quality of agreeing in all their circumstances but one; since the question put to nature becomes thereby more pointed, and its action more decisive.

A third rule is: Complicated phenomena, in which several causes, concurring, opposing, or quite independent of each other, operate at once, so as to produce a compound effect, may be simplified by subducting all the known causes, as well as the nature of the case permits, and thus leaving, as it were, a residual phenomenon to be explained.

It is by this process, in fact, that science, in its present advanced state, is chiefly promoted. A very elegant example may be cited from the explanation of the phenomena of sound. The inquiry into the cause of sound had led to conclusions respecting its mode of propagation, from which its velocity in the air could be precisely calculated. The calculations were performed; but when compared with the fact, though the agreement was sufficient to show the general correctness of the cause and mode of propagation assigned, the *whole* velocity could not be shown to arise from this theory. There was still a *residual* velocity to be accounted for. At length Laplace struck on the happy idea that this might arise from the heat developed in the act of that condensation which necessarily takes place at every vibration by

which sound is conveyed. The matter was submitted to exact calculation, and the result was at once the complete explanation of the residual phenomenon.

This is a specimen of the method according to which researches into causes are conducted. I add another example, exhibiting proportionality of cause and effect, experiment and residual phenomena, in one and the same set of inquiries.

In Sir Humphry Davy's experiments upon the decomposition of water by galvanism, it was found that, besides the two components of water, oxygen and hydrogen, an acid and an alkali were developed at the opposite poles of the battery. As the theory of the analysis of water did not give reason to expect these products, they were a *residual phenomenon*, the cause of which was still to be found. Some chemists thought that electricity had the power of producing these substances of itself; and if their erroneous conjecture had been adopted, succeeding researches would have gone upon the false scent of considering galvanic electricity as a producing rather than a decomposing force. The happier insight of Davy conjectured that there might be some hidden cause of this portion of the effect; the glass vessel containing the water might suffer partial decomposition, or some foreign matter might be mingled with the water, and the acid and alkali disengaged from it, so that the water would have no share in their production. Assuming this, he proceeded to try whether the total removal of the cause would destroy the effect, or at least the diminution of it bring a corresponding change in the amount of effect produced. By the substitution of gold vessels for the glass, without any change in the effect, he at once determined that the glass was not the cause. Employing distilled water, he found a marked diminution of the quantity of acid and alkali evolved: still, there was enough to show that the cause, whatever it was, was still in operation. Impurity of the water was not the sole, but a concurrent cause. He now conceived that the perspiration from the hands touching the instruments might affect the case, as it would contain common salt, and an acid and an alkali would result from its decomposition under the agency of electricity. By carefully avoiding such contact, he reduced the quantity of the products still further, until no more than slight traces of them were perceptible. What remained of the effect might be traceable to impurities of the atmosphere, decomposed by contact with the electrical apparatus. An experiment determined this: the battery was placed under an exhausted receiver, and when thus secured from atmospheric influence, it no longer evolved the acid and alkali.

An example like this brings into strong light many of the characteristics of inductive reasoning. The later steps tend to confirm the earlier, on which, however, they themselves depend; so that a mutual confirmation is obtained from setting them together. When the chemist substituted gold vessels for the glass, and inferred, from the continuance of the effect under this change, that the glass could have nothing to do with its production, it was possible, in the existing state of knowledge, that the

glass might be the cause, in one experiment, and the decomposition of the gold, in the other. But the later steps, which showed that the effect varied with the variations, in a circumstance wholly distinct from the decomposition of glass or gold, reduced the possibility of maintaining such a view to the lowest possible amount.

It may next be asked: How are causes discovered which are not obvious even after repeated inspection of the facts in which they lie hid?

The answer is: By a power, or combination of powers, granted only to a few, which has been called Anticipation; that is, the power of penetrating into the secrets of nature before the evidence is unfolded. It is enjoyed, as one might expect, by those only who have long and deeply studied the laws already laid open, but not even by all of these. It is no mere power of guessing, but the power of an active imagination, supplied with materials by a clear understanding, carefully disciplined. The system of Anatomy, which immortalized the name of Oken, is the consequence of a flash of anticipation, which glanced through his mind when he picked up, in a chance walk, the skull of a deer, bleached by the weather, and exclaimed, "It is a vertebral column!" When Newton saw the apple fall, the anticipatory question flashed into his mind, "Why do not the heavenly bodies fall like this apple?" In neither case had accident any important share: Newton and Oken were both prepared by the deepest previous study to seize upon the facts offered to them, and to show how important they might become; and if the apple and the deer's skull had been wanting, some other falling body or some other skull would have touched the string so ready to vibrate. But in each case there was a great step of anticipation: Oken thought he saw the type of the whole skeleton in the single vertebra and its modifications, whilst Newton conceived at once that the whole universe was full of bodies tending to fall—two truths that can scarcely be said to be contained in the little occurrences in connection with which they were first suggested.

The discovery of Goethe—which did for the vegetable kingdom what Oken's did for the animal—that the parts of a plant are to be regarded as metamorphosed leaves, is an apparent exception to the necessity of discipline for invention, since it was the discovery of a poet in a region to which, it was supposed, he had paid no special or laborious attention. But Goethe was himself most anxious to rest the basis of this discovery upon his patient observation, and doubtless with good reason.

As with other great discoveries, hints had been given already, though not pursued, both of Goethe's and Oken's principles. Goethe left his to be followed up by others, and but for his great fame, perhaps, his name would never have been connected with it. Oken had amassed all the material necessary for the establishment of his theory: he was able at once to discover and conquer the new country.

A mistaken notion prevails that this rapid anticipation does not belong to the philosophic cast of mind; that it is precisely what Bacon condemns as the method

which hurries rapidly from the particulars supplied by the senses to the most general axioms, and from them, as principles of indisputable truth, derives the intermediate axioms. It is thought that caution, and a deliberate examination of every particular we can find, before we allow ourselves to form any conclusion whatever, are the conditions of all sound physical inquiry. There is here a confusion of two distinct things: scrupulous caution should be exercised before a hypothesis is considered to be proved; and the law we believe to be true should be applied to every fact where it can be supposed to operate, and to every other law with which it might interfere, in order to verify exactly what was at first only a happy conjecture. This manner of proceeding is well exemplified in the discovery, made by Professor Horace Green, of the use of the sponge-probang in the topical treatment of diseases of the respiratory passages; that is to say, there was first a genesis of the anticipation, which was then tested in every case where it could be supposed to operate. Bacon meant to complain that this sober process did not always follow the bright thought and brilliant suggestion; and perhaps, also, that the bright thought itself was not always suggested in the region of facts, but only of words. When the ancient astronomy, rushing to the general axiom that "the circular motion is the most perfect," deduced from it the intermediate axiom that the motion of the heavenly bodies must be circular, it might be reasonably charged with an abuse of anticipation; because the highest axiom, having no precise and definable meaning, cannot have really sprung from the contemplation of facts, nor do it and the axiom drawn from it square with the facts they pretend to embrace. But, on the other hand, when these conditions are obeyed, Anticipation is, as it has been called, the mother of scientific discovery. "To try wrong guesses," says an eminent physicist, "is with most persons the only way to hit upon right ones." The character of the true philosopher is not that he never conjectures hazardously, but that his conjectures are clearly conceived, and brought into rigid contact with facts. He sees and compares distinctly the ideas and the things, the relations of his notions to each other and to phenomena. Under these conditions, it is not only excusable, but necessary, for him to snatch at every semblance of general rule, to try all promising forms of simplicity and symmetry. Anticipation, then, is the power whereby the mind presages a truth before it is fairly proved—before she proceeds to establish it by exact and cautious methods. Science works upon a system of credit: if she never advanced beyond her tangible capital, her wealth would not be so enormous as it is. She works with a principle as true before she knows it to be so, because, in watching how it operates upon facts, consist the best means of establishing its truth; but she must be prepared, at the same time, to abandon and dismiss it whenever it is proved to be in direct and irreconcilable conflict with established facts.

Granting, on the one hand, that the theory or conception which anticipation fur-

nishes to explain facts will be worthless unless it shall prove itself to be a fact, we must admit, on the other, that great steps of inductive discovery are made with the help of a preconception, and not by merely throwing observations together. That the fact of the elliptical motion of the planet Mars was not merely the *sum* of the different observations, is plain from this: that other persons, and Kepler himself before his discovery, did not find it by adding together the observations. The fact of the elliptical orbit was not the sum of the observations merely: it was the sum of the observations seen *under a new point of view*, which point of view Kepler's mind supplied.

Such a conception effects the colligation, or binding together, of the facts to be explained. But, in order to connect itself with the facts, the conception itself must be capable of definition; not, indeed, of *adequate* definition—since we shall have to alter our description of it, from time to time, with the advance of knowledge—but still capable of a precise and clear explanation. For example, a large class of facts is bound together by the notion of chemical affinity, and could not be understood without the thread of the conception to run through them.

No rules can be given for the discovery of the appropriate conception that explains our facts; such achievements appear to result from a peculiar sagacity and felicity of mind—never without labor—never without preparation; yet with no constant dependence upon preparation, upon labor, or even entirely upon personal endowment. The suggestion of the conception may be due almost entirely to accident; the explanation of it, often by far the most difficult step, cannot be accidental, but will proceed from a natural sagacity, highly disciplined by scientific pursuits.

The variableness with which the power of conception manifests itself is exemplified by what Goethe relates in his own case. "The quiet friend of nature," says that great man, "is not always in possession of himself; and from day to day the subject is clear or obscure before his eyes, in proportion to the greater or lesser activity of his intellectual powers. I shall make my subject more intelligible by a statement. Some time ago I was occupied in reading manuscripts of the fifteenth century, which are full of abbreviations. Although I had never applied myself to the deciphering of manuscripts, I set to work with great energy, and to my astonishment read off, without hesitation, unknown characters which ought to have been riddles to me. My success was not lasting. Some time afterward, when I wished to resume the same occupation, I found that I sought in vain to finish by labor and attention a task I had begun with spontaneous intelligence, rapidity, and ease. I therefore resolved to await the return of those fortunate and fugitive inspirations."

If we may find such differences in our facility of reading old parchments, the letters of which are fixed, how must the difficulty be increased when we strive to guess the secrets of nature—that ever-varying and coy nature which hides from us the mys-

tery of the life she bestows, sometimes unveiling what she had concealed, and at other times concealing what she had only the moment before unveiled! What man can boast that he is gifted with the wisely measured sagacity, with the modest assurance, which renders nature manageable at all times and in all places?

Conceptions not wholly correct may serve for a time for the colligation of facts, and may guide us in researches which will end in a more exact colligation. The theory of the *circular* motion of the heavenly bodies was of this kind, and, in its turn, the conception of epicycles. The theory of phlogiston in chemistry made many facts intelligible before the correcter one of oxidation superseded it. So with the theory of "nature abhors a vacuum," which served to bring together many cognate facts not previously considered as related. An incorrect conception of this kind has a place in science in so far as it is applicable to facts, and renders them intelligible. As soon as facts occur which it is inadequate to explain, we either correct it, or replace it by a new one.

Lastly, it may be asked, on what principle are incomplete inductions, or examinations of facts that stop short of complete enumerations, sufficient to establish general laws?

The answer is most important and interesting. All our experience teaches us that in the universe—the "Cosmos," whose very name means order—regularity and uniformity prevail, and caprice and uncertainty are excluded. Whilst it is conceivable that any one of the natural laws in which we have most confidence might be reversed, our present belief in their persistence is almost unlimited. The thought that there might be no more daylight if our planet ceased to revolve, whilst one side of it was averted from the sun—that a draught from the spring could to-day destroy the life which it recruited yesterday—that a stone, thrown from the hand, could remain suspended in mid-air, instead of falling—never enters our minds, except, perhaps, as an amusing fancy; yet each of these things is possible. Whence, then, our confidence in the uniformity of natural laws? It is embodied in the canon that, under the *same circumstances, and with the same substances, the same effects always result from the same causes.* But this great inductive principle is itself proved by induction, and partakes of the same defect that may be charged against inductive results, namely, that its terms are wider than our experience can warrant. Many groups of facts, connected as causes and effects, have not been examined; and in them it is conceivable, at least, that there may be causes producing opposite effects at different times. If this were otherwise, if the canon were a simple enumeration of all the possible causes, its present value as a rule would disappear, since it is to the unknown and unexamined cases that we chiefly wish to apply it. We draw a universal canon from an experience less than universal, and then employ it to justify us in drawing other universal truths from other particular experiences.

But here the relation of deduction and induction, between synthesis and analysis, comes to our assistance. These pairs of terms correspond exactly, as names for the same two processes; but induction and deduction give prominence to the law, analysis and synthesis to the fact. Thus we call the law of gravitation an inductive law, and speak of deductions from it, thinking more, in both cases, of the universal than of the particular cases it refers to. But we analyze a fact or a substance, and make a synthesis, that is to say, a placing together of the elements to reproduce the fact or substance. Using the two former names, the law is made prominent; using the two latter, we give prominence to the single fact. The supposed general principle may be tried by applying it to a new particular fact: the analysis of a fact into its elements may be tested by putting its elements together anew, and seeing if the fact is reproduced. And such experiments offer a twofold advantage. If, on applying some general law, of which we are still uncertain, to a new particular case, we find that it helps to explain the particular, this is one fruit of the process; another is that our confidence in the general law is materially strengthened. Law explains fact: fact confirms law. And after this alternate ascent and descent has been a few times performed, our belief in the correctness of its results is quite complete.

This process can be most readily understood from an example. The metal called potassium was discovered in acting on potash by the voltaic battery. But a mind disciplined to scientific inquiry saw at once that this single fact was an indication of a law. In the system of nature there is no caprice; if the power of yielding a metal belonged to this alkali, *as such*, beyond doubt other alkalies would participate in it. But the inductive argument is not strictly correct; for we cannot argue from a single alkali to all alkalies, and the property we have discovered may belong to this alone, in connection with some undiscovered peculiarity. How shall this be ascertained? By trying how the conclusion upon which suspicion rests will apply to new facts; by experimenting upon another alkali as if the law were already established; by deducing from it, as we have induced into it. The experiment is tried, and answers perfectly; and the success of the prediction operates strongly to raise our belief in the conclusion upon which it proceeded. That alkalies in general have a metallic base was first indicated by one fact alone, that of potash; but the chemist was guided by that fact to a second experiment, and now a second fact strengthens his belief that a law exists. To extend the trials to the alkaline earths is suggested by their similarity to alkalies; with them, too, the experiments are successful, and the law is considered to be established.

Two principles, then, are arrived at: that the correctness of the synthesis is proportionate to that of the preceding analysis, and that a doubtful analysis may be confirmed by a synthesis. In other words, a correct induction furnishes the basis for a sound deduction, and a doubtful induction must be verified by deductions from it.

Examples of this may be found on every side. The artillery-man, when he points a gun according to known rules, executes a synthesis of several laws—the law of gravitation, that of momentum, that of atmospheric resistance. If his shot misses, it will be either because some element has been left out of the analysis—the comparative force, perhaps, of different sorts of powder, or the windage of a loose ball in the barrel of the piece—or because the influence of each of the known laws has not been duly apportioned. The theory that marble is carbonate of lime, fused under extreme pressure, has been made highly probable by the synthetic experiments of Sir James Hall, who made a substance closely resembling marble by these means. A correct analysis of *lapis lazuli* was suspected to be erroneous, because there seemed to be nothing in the elements assigned to it, which were silica, alumina, soda, sulphur, and a trace of iron, to account for the brilliant blue color of the stone: accidental synthesis, which was followed up by intentional, reproduced it, and thus the analysis was found to be correct, whilst the synthesis is now daily performed for commercial purposes. The law that the planets are retained in their orbits by an attractive force that varies inversely as the squares of their distances from the sun, was worked out to its theoretical results, and these were compared, synthetically, with the known facts. Theory was not found to correspond with fact in all respects, and thus it became necessary to revise the analysis, and discover the residual causes that produced the variations, which astronomers succeeded in doing.

By the mutual co-operation of these two processes, the physical sciences are advanced. If no attempts were made to draw a conclusion, and see what use could be made of it, till complete grounds were before us, conclusions would never be drawn. The certainties by which the chemist, the astronomer, the geologist, conducts his operations with composure and success were once bare possibilities, which, after being handed back and forward between induction and deduction, turned out to be truths.

A phenomenon strikes your senses: you observe it, with the intention of discovering its cause, and, to do so, you *suppose* one, to be verified by instituting an experiment. If the hypothesis be not well-founded, you make a new one, which you submit to a new experiment, and so proceed until your object is attained—that is to say, if the actual state of science will permit it. But to proceed in this manner you must possess the scientific ability to institute experiments, and also the art of performing them with precision; for experiments verify a hypothesis only on condition that they have themselves been submitted to a series of experimental counter-tests of such a character as to establish their correctness. Thus, then, ratiocination, inductive or deductive, suggested by the observation of phenomena, institutes experiments which enable us to assert the causes upon which the phenomena depend. This method of proceeding constitutes the experimental method, because, definitively, experiment is the test or criterion of the correctness of our ratiocination. The experimental method,

thus defined, is applicable to the group of sciences called sciences of observation and ratiocination. In some, the application has not been made; such as the sciences of geology, botany, and zoology, which are not now, whatever they may become hereafter, sciences of experiment, as well as of observation and ratiocination. It follows that a branch of human knowledge to which the experimental method has not been applied has not as yet a complete scientific character. It may acquire it one day, but in the mean time it cannot be taught with that degree of gravity and luminous exposition which pertains to the sciences of higher development, such as chemistry and physiology. Medicine, also, including surgery, fulfils the three conditions of an advanced science; for it observes, ratiocinates, and experiments: observation being applied to the phenomena of disease; the ratiocination being for the most part inductive; and the experiment, the therapeutic treatment. Such, at least, is Rational Medicine. When the therapeutic treatment is not the experimental test of a ratiocination, but is, nevertheless, sanctioned by a certain amount of experience, medicine is empirical; but when the treatment is wholly isolated both from ratiocination and experience, medicine becomes quackery; of which immoral and opprobrious practice this is a strict and adequate definition.

Scientific truth being the result of investigations made by the experimental method, there can be no sound instruction conveyed which does not rest upon this method as a basis. For the advantages and uses of true science are, that it consists not only in preventing error in regard to those things that are already known, but also in enabling the mind to distinguish what is true or probable from what must be erroneous in respect of those things which are still involved in obscurity. In this latter case, patient and deep investigation becomes indispensable, and the habit of experiment, acquired in early life, will be efficient in putting the student upon the track which leads to the discovery of the unknown truth.

Of course conjecture and hypothesis have their use; but it the conclusion which is derived from them be given as the expression of positive truth, it will produce all the bad effects of ascertained error, especially if it meet a certain direction of public sentiment or expectancy at a certain epoch; for, then, opinions without any real foundation will receive from the theories which are invoked in their support a sort of consecration. We have only to cast our eyes abroad on the surface of society to recognize the truth of this proposition.

The doctrine of progress, for instance, as defined and understood by many, is derived from theories which have not been tested by experiment; consequently it has conferred no advantage on society. Its influence is exercised in disparaging the past, and making light of the undeniable good which exists in the present—when its apostles do not claim to be the authors of that good. But a doctrine of progress ought to be an exposition of the causes which have ameliorated society in its moral, mate-

rial, and intellectual development, and such an exposition will be wanting in meaning if, among other things, it has not for its object to make men feel how much they owe to the authors of that development. It embraces, therefore, a historical part, and, also, a moral part, the tendency of which should be to present the benefactors of humanity to our moral approbation. I need scarcely remind you that a prevalent idea of progress is directly the other way, and that its tendency is to extol the future, to the exclusion of the past and present. This tendency originates in ignorance or dishonesty. In either case it leads to error and injustice. We are not within the limits of truth in dating progress from the epoch in which we live. It begins with the origin of every community, and is so much the necessary consequence of the organization of man and of his specific nature, that we find it in every association that attaches itself to a particular soil and expands by successive generations. *Art is the nature of man.*

Let us examine for a moment what progress really is, and seek its causes by ascending to the past; that is to say, by following the inductive method as our safest guide. The cause of the most direct, as well as the most lasting, influence of the nations of antiquity upon the civilized nations of the actual world, was exercised by intellectual labors, with each of which the name of an individual is associated. Thus, religion had Moses for its exponent: poetry, Homer: history, Herodotus: philosophy, Plato: science, Archimedes. As regards religion, no influence is comparable to that of the people of Israel; while as regards letters and the fine arts, none is comparable to that of the Greeks. But what part had the ancients in the cultivation of sciences? In pure mathematics, and even in mathematics applied to astronomy and mechanics, in cases where instruments are not required, ratiocination discovered a great number of truths. The discoveries of Euclid in elementary geometry, and of Archimedes in geometry and mechanics, place their authors in the first rank of intellectual power. The genius of antiquity reached, also, the highest point of elevation in the treatment of those capital questions which are outside of pure mathematics, and of the sciences of observation, ratiocination, and experiment. Whatever system of philosophy we may profess, Plato and Aristotle will always be men of the first order. In a word, antiquity showed immense power in the development of the method of deduction when applied to speculative philosophy, and to the proof of propositions resulting from definitions made in conformity with the laws of thought. Lastly, antiquity attained the extreme limits of the sublime and beautiful in poetry, architecture, sculpture, and, perhaps, in painting.

But the aspect under which the ancients present themselves in the cultivation of the sciences of observation, ratiocination, and experiment is not equally brilliant. Here their inferiority to the moderns is clearly manifest; but while recognizing this inferiority, we must not imagine that it proceeded from inaptitude; for the history

of animals by Aristotle testifies to the superior manner in which he was capable of handling questions accessible to simple observation, and to what he might have accomplished had he possessed instruments of the same precision as are employed at the present day. We might also refer to real experiments in physico-mechanics performed by Pythagoras, when he showed the relation existing between the sounds rendered by chords and the weights which distend them.

The inferiority of the ancients in the sciences of observation, ratiocination, and experiment is to be attributed to many causes; but the principal one was the almost exclusive use they made of the *a priori* method. To this may be added the influence of the master upon the disciple; so great, for instance, in the school of Pythagoras, that it was only after many years of trial the pupil was judged to be in a fit state to receive the first teachings of his master. Another cause of this inferiority was the tendency of the ancient mind to absolute opinions. For instance, so long as the magnet continued to be regarded in merely an absolute point of view, it was defined to be a body which had the property of attracting iron; but magnetism did not assume a scientific character until the magnet came to be considered in a correlative point of view—that is to say, when it was seen that the bodies which act upon iron have two magnetic states; so that if iron be attracted by the pole of a magnet, that part of the iron which is attracted has a different magnetic state from that of the pole of the magnet toward which it is drawn. It then became possible to define the magnetic property, by asserting that the bodies which manifest it are in two states. When they react, with their parts in the same state, there is repulsion; whilst there is attraction when they react with their parts in different states. The magnetic property, considered in an absolute point of view, belongs to the infancy of science—an infancy which lasted for ages—whilst the definition of the two magnetic states, in the correlative point of view, is the conclusion of progressive science. The electrical properties of bodies, and chemical properties of the greatest generality, occupy precisely the same position as magnetic properties.

The middle ages accepted submissively the teaching of antiquity, and under the sanction of the Roman theocracy the authority of Aristotle was absolute in the schools. But, by degrees, out of the admixture of the nations which occupied the soil of Europe arose a new civilization, and out of the multiplied relations of men holding a common faith arose the sciences of observation, ratiocination, and experiment, to which we are indebted for a control and use of the forces of nature which neither antiquity nor the middle ages conceived to be possible. These sciences came into existence as soon as men became aware of the insufficiency of the *a priori* method to explain the most ordinary phenomena pertaining to natural philosophy. It is the glory of Bacon that he proclaimed the incompetence of the old method, and recommended experiment as the means of unfolding scientific truths.

Thus the history of the human mind embraces two principal epochs: that which preceded the era of the experimental method; and that which, commencing with it, will endure so long as man shall desire to know the world in which he lives. But we cannot afford to sacrifice one of these epochs to the other, for we are equally their debtor: to the first, for its models of the sublime and beautiful in poetry, eloquence, historical narrative, architecture, sculpture, and philosophy; to the second, for its immense development of the natural sciences.

Such is progress, viewed in its greatest generality, and studied in its details by the light of the inductive method—that is to say, by ascending from effects to their causes, and thus reaching, in a measure, the cradle of human intelligence. This manner of proceeding will enable us to perceive the slowness of progress, its prolonged struggles, and how little it owes to any one individual. For however great may have been the performance of the discoverer, he in every case received vastly more from his precursors and contemporaries than he has left to posterity. Is public opinion always conformable to this view of progress? Assuredly it is not. For instance, the majority of men are filled with extravagant wonder at such results as steam locomotion and the electric telegraph, because they are ignorant of their antecedents; but the wise man, who is not ignorant of them, is moderate in his approbation, and declines joining in the acclamation of the multitude. Besides, men do not sufficiently consider the immense superiority of discoveries of laws of nature over mechanical invention, however ingenious. But Archimedes, himself one of the greatest inventors the world has ever seen, esteemed mechanical inventions greatly inferior in value to those speculations which carry irresistible conviction to the mind. Hans Christian Oersted used to call the year 1820 the happiest year of his life, because in that year he discovered *electro-magnetism*, or the law of reciprocity between electrified bodies and the magnet. "It was in the deep recesses, as it were, of a cell," says Sir John Herschel, "that in the midst of his study a far idea first struck upon the mind of Oersted." He waited long and calmly for the dawn which at length opened upon him, altering the whole relations of science, and, indeed, of life. The electric telegraph, and other mechanical inventions of recent date, are but mere effervescences from the surface of this deep, recondite discovery which Oersted liberated, and which was yet to burst with all its mighty force upon the world.

If men possessed science enough to be able to foresee, to some extent at least, the consequences of a capital discovery, made by abstract science, they would never ask, *Of what use is it?* and still less would they prostrate themselves before mechanical inventions the merit of which is exaggerated by friends or interested judges. Better prepared to see consequences in the one case, they would, in the other, be more capable of enlightened appreciation. While, also, they would be less astonished than they are by the practical results of great discoveries made in the domain of nature,

they would be enabled to see, in regard to those discoveries themselves, how small is the part of chance, how great the part of pure science. And in regard to utility, is it not because the Chinese despise abstract science that their arts ceased in their development some centuries ago, and have not the progressive character which the same arts exhibit among the nations of Christendom, owing to the marvelous influence exercised by the mathematics, physics, and chemistry? Thus, even in a purely moral point of view, it is evident that the more we are taught in our study of the law of progress to ascend from effects to their causes, the greater will be our respect for pure science, because we shall be more capable of appreciating its influence upon the condition of humanity.

An enlightened public will not believe in a complete man. It will never ask who is the greatest poet, the greatest historian, the greatest painter. By this we do not mean that the public, by becoming enlightened, will lose its admiration for men of talent—for those who occupy the first rank in letters, art, and science. On the contrary, being less absolute in its judgments, it will count many eminent men in the same department of human knowledge; and thus furnished with numerous objects for comparison, it will find new enjoyments of a highly rational kind in observing the diversity of means employed by men of great gifts, in addressing the reason, the imagination, and the heart, and, I may add, in observing the diversity of merit possessed by men whose profession it is to alleviate the ills to which humanity is heir. Comparisons made in this spirit, without abasing the merit of one in proportion as we exalt the merit of another, have the advantage of satisfying the conscience that we are within the limits of truth; whilst when the opinion we entertain is absolutely opposed to another, the result is to establish two categories of judges, one only of which has common-sense—that, of course, to which we ourselves belong.

If a moderate amount of self-esteem be a beneficent provision of nature, it is equally true that the exaggeration of it is pernicious to the individual and to the society of which he is a member. The overestimation of one's own merit leads man to isolation. When he does not become hostile to the past he despises it, or sees nothing in it deserving his respect; and as for his contemporaries, he does not like them, unless, indeed, they belong to the same sect as himself. Isolation fills him with unmeasured ambition for his own elevation at the expense of his fellow-men, for whom he has no care. It engenders an opposition to law and authority, an opposition which is based upon a false interpretation of the doctrine of progress. In fact, we find that numerous classes—in one conspicuous case having an almost independent political status—denounce the actual condition of society, because, impressed with the successful applications of abstract science to the mechanical arts, they believe that society can be ameliorated with the same facility that matter is modified when it obeys the commands of man, delivered from the sanctuary of science! These decep-

tive analogies between things really heterogeneous explain the sympathy felt for systems which, although in contradiction with human nature, flatter our illusions by promising what man cannot give, and which, therefore, it is unreasonable to hope for.

Now is it not manifest that whatever shows the weakness of the individual in the work of humanity is a testimony to the power of association, a protest against the abuse of self-esteem, and a motive for uniting ourselves more closely than ever to our fellow-men? But it is precisely by means of the inductive method applied to the study of progress that the weakness of individual reason is demonstrated. It points out the benefits of association, by showing that the greatest work of the greatest individual man could not have been performed at a given epoch without the assistance of his precursors and contemporaries. In this relation the history of the human mind, inductively considered, concurs with the Christian pulpit in attesting the weakness of man even in his greatest triumphs.

I would therefore say to you: Admire the grand intellects that have existed in the past, and honor their memories for the advantages you have derived from them. And if you survey your contemporaries, you will see many who are entitled to your admiration for their genius, and to your respect for their character. But recollect that this genial view of your fellow-men will chiefly depend upon the degree of cultivation you yourselves possess. *When a man's own mind is polished, it reflects the brilliancy of other minds; but common people see no difference between man and man.*

ELEPHANTIASIS ARABUM

OF THE

RIGHT INFERIOR EXTREMITY:

SUCCESSFULLY TREATED

BY LIGATURE OF THE FEMORAL ARTERY.

The treatment of Elephantiasis Arabum by cutting off the supply of blood to the diseased parts by ligature of the main arterial trunk, the branches of which are distributed to the hypertrophied tissues, is a proceeding now so well established by frequent repetition that the efficacy of such a curative method can no longer be doubted.

Since the publication of the first case treated upon this principle by myself, in 1851, different surgeons have put the same mode of treatment to the test, and almost invariably with favorable results. If in some instances the disease has not been entirely cured, it has been diminished in size, and kept at bay so that farther hypertrophic growth has ceased; the complete restoration of the parts to their normal dimensions having been impeded or prevented by an anomalous arterial distribution or by the ligature of the main artery being placed among the diseased tissues instead of entirely beyond them on the cardiac side, thereby insufficiently intercepting the supply of blood.

At the converging or terminal limit at which the progressive metamorphosis of the materials carried into the system for the purposes of restoration and repair ends, and the retrogressive metamorphosis begins, which, by secretion and excretion, eliminates the effete elements no longer of use in the system, a physiological balance of synthesis and of disintegration of elements must exist, or, in default of this condition, morbid phenomena in some form

or other will begin to be manifested. By progressive metamorphosis I mean to express the different changes by which the materials of the blood are converted into the elements destined for the repair of the tissues, while retrogressive metamorphosis is understood to embrace those changes which take place at or upon the return, through the channels of circulation, of those effete elements contained in the blood which have not been utilized for the reparation of the tissues, and which ultimately are eliminated from the body. The controlling influence which presides over this normal equilibrium is supplied directly from the nervous system to the parts or tissues undergoing the physiological or healthy change. If, however, from the intercurrent action of some abnormal perturbating cause, the fundamental source of nervous supply shall become abnormal, and the function of the nutritive capillaries shall become disturbed, some pathological phenomena are sure to present themselves by functional or organic irregularity. Thus we may have as a result homological growths composed simply of the normal tissues, more or less hypertrophied, or an atrophy may take place, or heterologous formations may be developed, composed of structures foreign to the original histological characters, revealing the malignant traits of scirrhus, fungus hæmatodes, or other cancerous or destructive formations in their various modifications. It is by a train of reasoning in this direction that we may account for such a hypertrophied condition of the tissues as is met with in Elephantiasis Arabum, and it is upon a theory so founded that the therapeutic indication is deduced of modifying the nutrition of the parts by lessening the amount of the arterial supply.

Below is recorded the first case of Elephantiasis treated in this manner, as originally published, the entire success of which is, from its extended character, to be attributed probably to the application of the ligature to the external iliac artery, on account of secondary hemorrhage from the femoral.

[*From the New York Journal of Medicine, Sept.*, 1852.]

Elephantiasis Arabum, so called in contradistinction to Elephantiasis Græcorum, because its history was first described by Arabian authors, is a malady the etiology and pathology of which are not definitively understood

at the present day. The treatment also remains uncertain; and when the disease has existed for any length of time, it is generally looked upon as irremediable by any other means than amputation of the tissues or of the member involved. This malady is not confined in its attacks to any particular part of the body; the vulva, the scrotum, and the inferior extremities are, however, the principal seats of the disease. When affecting the lower extremity, its peculiar form, which is somewhat like the clumsy appearance of the elephant's leg, suggested the name of Elephantiasis.

Elephantiasis of the Arabs is said to be uncommon in Europe, and as respects this country, I am not aware of its occurrence endemically in any part of it. Insulated cases, however, certainly do present themselves. Within the last three years five marked cases have come under my observation; of these, in two instances, the malady showed itself in the scrotum, and in the other three, the seat of the disease was in the inferior extremity. Four of these cases became developed in persons residing in different parts of the United States: one in New York, one in Florida, one in Virginia, and one in the State of Pennsylvania; the other case occurred in a patient who was a native of Ireland, and who imported the disease with him. These patients were all adult males, and the circumstances preceding the development of the disease in each case were generally dissimilar; thus, in the cases where the inferior extremity was affected, the disease in one became manifested after an attack of paludal fever; in another, also after a febrile attack; and in the third, after the individual had been working for some time at an occupation requiring him to stand for hours with his legs immersed in water. In one of the two cases where the scrotum and integuments of the penis were affected, the elephantiasis was preceded by a scrotal hernia, and by an attack of syphilis, while the other was associated with, and preceded by, a large hydrocele of the tunica vaginalis testis.

Climate cannot be said to have exerted any influence, as the cases occurred in different localities. The accounts, however, related of this malady will not allow us to doubt that it is met within certain latitudes and localities more frequently than in others. In the West Indies, some parts of Asia, and among the Arabs, it is found to exist endemically; but although this fact is

established, and points to the influence of climate, what that influence is, and how it operates, remain unaccounted for with any degree of certainty. The enlargement of the thyroid gland, which occurs in certain parts of Europe and North America, is ascribed to the drinking of snow-water and of water impregnated with calcareous or earthy particles; while in the equatorial or tropical regions the prevalence of elephantiasis is attributed to the alternations of heat and cold. But these speculations, resting as they do upon no positive data, are extremely vague, and thus, both as regards the more frequent occurrence in certain localities and as regards the difficulty of accounting for the influence of climate, elephantiasis and bronchocele, both hypertrophic conditions of the tissues, appear to have some analogy to each other.

The production of the disease has also been attributed to the obliteration of the veins of the members affected, and likewise to chronic inflammation, commencing at the dermoid structure, and extending, by contiguity of tissue, to the subcutaneous layers; but again it must be remarked that no fixed invariableness of antecedence has been observed. One fact which may have some bearing upon the etiology of the elephantiasis, and to which I shall again presently allude, has been generally overlooked. I refer to the morbid condition and dilatation of the principal arterial trunk of the member affected. The disease has also been supposed to arise from frequent attacks of erysipelas; and, as another cause, from subinflammation of the absorbent vessels and lymphatic glands.

Elephantiasis, as in two of the cases which came under my observation, is sometimes rapid in its accession or invasion, and when occupying an extensive surface, the constitution participates in the local affection. The skin assumes no erysipelatous hue; but the subcutaneous tissues become engorged, tumefied, and tense; while the course of the lymphatics, if the seat of the malady be on a limb, is marked by nodulated cords; and the glands of the groin or of the axilla may also become affected and enlarged; these various symptoms being ushered in by a deep-seated and violent pain in the region of the disease.

If the disease, after the acute stage, does not recede, the intumescence remains, although the other symptoms may subside for a time. Exacerba-

tions recur at intervals, varying in duration, and the enlargement of the tissues increases, until the structures invaded remain, as it were, stationary in their abnormal condition, imparting to the hand when examined a harsh, dense, pachydermatous sensation, and presenting to the eye, in the most characteristic form of the disease, a rough, scaly, dusky-looking mass of deformity, well represented in the accompanying illustration.

If the disease progresses no farther than has just been described, the enlargement of a limb or of the scrotum remains an insufferable encumbrance; while, in the uninterrupted progress of the disease, fetid and incurable ulcerations may occur, abscesses may take place among the morbid tissues, and the internal organs may become disordered. The prognosis, consequently, must be unfavorable when the disease has existed for some time, and assumed its characteristic, chronic, and intractable form.

In the early stages of the disease it is possible that it may be confounded, especially in females, in whom the subcutaneous strata are usually thicker than in males, with diffuse and deep-seated inflammation of the cellular tissue, or with œdema or anasarca. The history and progress of the disease, the sensation imparted, upon examination, by the tumor, and the peculiar local traits, generally suffice to enable the practitioner to discriminate without much difficulty between elephantiasis and the other diseases just named.

It would appear, from the different accounts given of this disease, that the whole of the tissues of a member may become ultimately implicated. Some are primarily affected, while others, such as the bones, are probably not involved in the morbid degeneration until the disease has been of long standing. The tissues primarily affected would seem to be the vascular; and the pain, redness, and hardness met with in the first stage of the disease, in the course of the lymphatic vessels, together with the appearances of the veins upon autopsy, as mentioned by Bouillaud and others, evince with sufficient certainty a pathologic condition of the vessels. The arteries also participate in the disease, and very probably at an early stage of its invasion.

The skin generally shows early participation in the malady; most commonly the development of the initiatory stage is accompanied by some form

of cutaneous affection, such as eczema, erysipelas, lichen, or ulceration. These affections occur, however, so frequently without any of the hard and bulky intumescence characteristic of elephantiasis being manifested as a sequent, that it is reasonable to suppose they are accompaniments merely of disease of the deeper-seated tissues, especially of the vascular tissues, upon which, in reality, the elephantiasis depends. The different strata of the skin are hypertrophied to a considerable degree, the epidermis presenting a series of dusky, hard, superimposed scales. This condition of the epidermis, however, is not always present, especially when the scrotum is the seat of the disease. The subcutaneous adipo-cellular layer is blended with the dermoid tissue, so as to form a hard, dense, and lardaceous mass of irregular thickness; the subaponeurotic and intermuscular cellular tissue becomes changed and hypertrophied; the muscles also are in the progress of the disease perverted, becoming softened and less deeply colored than in their normal condition—sometimes being converted into fatty tissue, at others into an indurated formation, and even, at times, exhibiting deposits of bony material. The nerves are sometimes found to be increased in size; the bones are sometimes found unaltered, and sometimes are found increased in size; and, lastly, the interosseous ligament is at times found ossified. Lesions of the internal organs are not so frequently found to accompany Elephantiasis Arabum as the other form, known as Elephantiasis Græcorum; still, diseases of the internal viscera are seen as complications of the former, when the malady has existed for a long period.

In its initiatory stage, the treatment of elephantiasis, regarded as a *phlegmasia*, should be conducted upon antiphlogistic principles; thus, bleeding, emollient applications, tepid baths, and the vapor *douche*, are recommended and resorted to. In the more chronic stages of the malady, compression, combined with scarifications and local bleeding, is said to be useful. Iodine frictions and the vapor douche appear to merit most attention, having, upon good authority, been used advantageously in cases of genuine elephantiasis.

When the disease has resisted every rational curative method, and when the part attacked has attained a size which, by reason of the weight of the mass, renders it an unmanageable encumbrance, as happens in elephantiasis

of the scrotum and of the inferior extremities, amputation is advised and practised as the only alternative. But this extreme resort is not usually attended with success, the disease generally returning upon some other member with all its original inveteracy and obstinacy.

In the following case, which came under my management, I resorted to a method of treatment which, as far as I know, is entirely novel, and which, both for this reason and because it terminated in the perfect restoration of the diseased and cumbrous limb to its normal condition and functions, I have thought deserving of publicity.

The accompanying drawing of the limb of the patient, taken from nature (*vide* Plate No. 1), gives an accurate representation of the disease.

Case.—Charles Roller—of lymphatic temperament and short stature, æt. 27, born in Aix-la-Chapelle, occupation, merchant—left his home in December, 1849, landed in New York in February, 1850, went thence to Connecticut, where for some months he worked in a factory, standing during his hours of labor; thence went to Virginia, where he worked on a farm for about six months, at the expiration of which period he was taken with fever of an intermittent character. Up to that time he had always been in good health.

During the fever the inguinal glands on the right side became swollen and painful, the swelling and pain extending in the course of the femoral vessels as far as the knee. The pain was followed by swelling and redness of the thigh down to the knee. From the knee the pain and swelling continued to extend downward as far as the toes, being at this time confined chiefly to the portions of the limb along the course of the saphena vein, and also of the posterior tibial vessels. The redness and tumefaction here, as in the thigh, were preceded by deep-seated pain. The tumefaction of the limb continued to increase, while at the same time febrile exacerbations occurred at intervals, varying from two to six days. After a period of about six weeks from the commencement of the disease, the fever entirely disappeared, and by that time also the pain and redness had entirely ceased; the limb, however, remaining hard, swollen, and rough, and presenting in a marked degree the peculiar characteristics of Elephantiasis Arabum in the chronic

period of the disease. From that time forward the hardness and intumescence gradually increased, and the limb became so cumbersome that the patient was obliged to give up all business, and confine himself chiefly to a recumbent posture. In this condition the patient left Virginia for the purpose of seeking medical relief at the New York Emigrants' Hospital, into which he was admitted the 15th of January, 1851. The appearance of the patient upon entering the hospital was somewhat emaciated. He had no febrile symptoms, and the chief difficulty under which he labored arose from the enlarged and hypertrophied condition of the right inferior extremity.

The limb was enlarged from the toes to within a short distance below Poupart's ligament. The thigh, although enlarged, was not much indurated; while from a short distance above the patella downward the limb presented a dense, hypertrophied, hard, scaly, shapeless mass, the appearance of which will be best apprehended by referring to the accompanying plate.

The morbid condition of the tissues pervaded the foot and toes, there presenting groups of tuberculated growths. The circumference of the limb around the ankle was nearly as large as that of the calf, measuring fifteen and one-half inches; while the circumference of the calf measured nineteen and one-half inches.

The patient was put under treatment upon entering the hospital. The recumbent posture was enjoined, and for some time various discutient lotions were used. Bandaging was resorted to, with frictions of ung. Potass. Iodid.; the Iodide of Potassium being also prescribed internally.

At times, also, the limb was painted with strong tincture of Iodine; local and general baths were used; regular bandaging of the limb, from the toes upward, being the while carefully observed.

This plan of treatment was perseveringly adhered to from the 15th of January to the 22d of March, a period of a little over two months, without any amelioration. Having thus tried, without success, the method of treatment most approved of, I proposed to place a ligature upon the femoral artery, with the view of changing the morbid condition of the structures supplied by the branches of this arterial trunk. A consultation was held, and my proposition was acceded to as preferable to amputation, the usual alternative

resorted to in this stage and extent of the disease. Accordingly, on the 22d of March, 1851, I secured the femoral artery, a short distance below the origin of the arteria profunda. Upon exposing the femoral artery, this arterial tube was found to be changed, so as to present an appearance somewhat like the color of the aorta of the ox, and to be larger than the common iliac of the human subject. In consequence of this appearance of the artery, after some hesitation I applied the ligature, preferring to do this rather than to expose the external iliac, of the soundness of which I could not be certain.

The ligature came away from the femoral artery on the eleventh day, accompanied by secondary hemorrhage, the occurrence of which I had expected as probable. For the purpose of arresting the hemorrhage, the *external* iliac artery, which was found to be smaller than usual, about the size of the brachial artery, was secured by ligature. This, for a time, apparently had some influence upon the hemorrhage; but on the following day bleeding was again renewed from the orifice in the femoral artery, with as much profusion as ever.

The hemorrhage was now restrained by the prompt application of a tourniquet on the *cardiac* side of the bleeding orifice, by the house surgeons, Drs. Thompson and A. K. Smith.

This even failed to stop permanently the hemorrhage, and the blood recommenced oozing copiously at intervals. The patient was now sinking fast, and the ligature of the common iliac, or amputation at the hip joint, appeared to be the only resources left. But the hemorrhage now being evidently reflux, it was suggested to apply the tourniquet, so as to produce compression on the *distal* side of the bleeding orifice: this was done, and was followed by a complete cessation of the bleeding.

From that time (April 4th, 1851) the house surgeon kept an instructive record of the case, which I have now before me. For several days the pulse ranged from 115 to 108: the dressings were carefully attended to, and light diet prescribed. On the twelfth, the leg was found to be considerably reduced in size, and the ligature of the external iliac came away. On the seventeenth, brandy and quinine, with good nourishment, were ordered. On May the first, finding the leg still more reduced and the lower wound healed, I ordered

tincture of iodine to be painted on the leg, and the bandage to be continued; I also ordered a solution of chloride of soda to be used as a wash on the upper wound, which continued to discharge freely.

The patient now went on gradually improving in strength and appearance, and left the hospital, in the latter part of June, completely cured of his malady. At this date, sixteen months after the ligature of the femoral artery, the patient is in robust health, and presents no indications that the disease will return.*

[*From the New York Medical Gazette, Jan.*, 1858.]

In September, 1852, I recorded a case of Elephantiasis Arabum successfully treated by ligature of the femoral artery. Since then I have received a letter from Professor Erichsen, of the London University, in which he mentions a case of elephantiasis treated, with a successful result, upon the same principle.

The portion of his letter referring to this subject runs as follows: "I have perused the details of your cases with great interest, and have been especially struck by the account of the successful ligature of the femoral artery for that otherwise intractable disease, Elephantiasis Arabum. The operation was certainly a bold step, but one that the result shows to have been the proper one to take; and it certainly does infinite credit to your judgment and skill to have devised a successful treatment for this complaint. I have at present under my care a man with extensive elephantiasis of the foot, in whom, about two months ago, the assistant surgeon, during my absence, tied the anterior tibial, in the middle third of the leg. This case has done well, and the limb is fast recovering its usual dimensions. The operation was performed on hearing of the success of your case."

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* Afterward, I may add, at this date, December, 1876, that he acted as my valet for over a year, wearing boots of equal size purchased ready-made, without reference to his former diseased limb. When he left me, he returned to his own country.

The following case is another example of the beneficial results of this practice, in a disease hitherto deemed incurable by other means:

Francisco Podesta, a native of Italy, 39 years of age, peasant by occupation, was admitted into the State Emigrants' Hospital on the 17th of April, 1857. About six years previous to his admission, after prolonged exposure to cold and dampness, he was attacked with severe pains in the left leg, extending upward along the thigh. The pain was followed by general tumefaction of the leg from the toes upward to the knee joint. The local disease was attended by constitutional disturbance, which, however, gradually subsided, the limb remaining much disfigured and considerably larger than that of the opposite side. The foot was thickened, and appeared stunted, from the increased circumference around the ankle; the calf of the leg was also considerably enlarged; the skin and subcutaneous tissues were dense, hard, and hypertrophied; the surface of the limb below the knee was scaly, and in general presented the unseemly appearance from which the term elephantiasis has been derived. Around the ankle the hypertrophied tissues were thrown into large and prominent folds, hanging, as it were, over the ankle joint; between two of these folds an extensive ulceration existed, as large as a dollar piece. The patient, in this condition, was unable to follow any vocation; in fact, was unable to walk, and entered the hospital more as an asylum than with the hope of obtaining relief. His general condition was feeble, and he presented a cachectic appearance. The following were the measurements of the limb: the thighs at the middle were of equal measurement, 19 inches; around the calves—on the sound side, 10 inches; on the diseased side, 13 inches; above the ankles—on the sound side, 8¼ inches; on the diseased side, 12 inches; around the ankles—on the sound side, 9¼ inches; on the opposite side, 15½ inches; while the measurement from the heel around the instep on the sound side was 12 inches, and 19 inches on the diseased side.

Deeming it unnecessary to repeat in this patient's case the numerous remedies which had been unavailingly tried, I proposed to apply a ligature upon the femoral artery for the purpose of modifying the morbid nutrition of the limb. Allowing him some time to improve his general health and to

become accustomed to the air of the hospital, on the 23d of May a ligature was applied on the femoral artery in Scarpa's space. The artery was found to be healthy and of normal size. May 27th: Every thing had progressed favorably up to this time, and the limb was beginning to show evidence of diminution. July 1st, the ligature came away; at this time the calf of the diseased side had diminished 1 inch above the ankle; around the ankle, $1\frac{3}{4}$ inches; and in the measurement in the heel around the instep, $3\frac{1}{2}$ inches; the skin of the leg and foot was also soft. July 10th, the patient was allowed to move about; the ankle joint, which previously was almost immovable, now admitted of flexion and extension. The ulceration had now healed, and from that time forward until the 24th of August (the time of his discharge from the hospital) the dense and hardened tissues were gradually becoming more natural and soft. He left the hospital with his limb almost of natural size, and able to walk with but slight lameness.

Since the publication of the last case I have repeated the operation of tying the femoral artery in three instances for the cure of elephantiasis. These cases occurred in two young women, one of whom had the disease on one inferior extremity; the other had both of the lower limbs affected.

The following is a brief history of these cases:

Ann O'Brien, native of Ireland, domestic, aged 25 years, apparently in robust health, had had one child, was admitted into the hospital on the 27th November, 1857. She stated that she had suffered considerable pain in the right leg during the last five years. About twelve months ago the leg began to enlarge, and continued to do so until the time of her admission. At that time the foot, especially on the dorsum, was considerably enlarged. Above the ankle the leg was much increased in size, the skin there presenting thick pachydermatous folds hanging over the ankle joint, so as to prevent the motion at the articulation. The enlargement of the limb extended upward above the knee as far as the middle of the thigh, and she was totally unable to perform her duty as a domestic.

The following measurements of the diseased and sound limbs were taken previous to the operation, which was performed on the 12th December, 1857, by applying the ligature around the artery in the Scarpa's space:

The diseased side measured, around the middle of the thigh, 20¾ inches; the sound side, 19¼ inches; above the knee of diseased side the measurement was 15½ inches; on sound side, 14¾; immediately under the knee, 13¾ inches on diseased side; on the other side, 13 inches; at middle of calf, 14 inches on diseased side; on sound side, 13 inches; below the calf, on diseased side, 13¾ inches; on the other side, 10¼ inches; around the ankle of diseased limb, 11¾ inches; on the other side, 8⅞ inches; around instep on the diseased foot, 11 inches; around the other, 9½ inches; around the toes of diseased foot, 9¾; around the other, 8¾.

The femoral artery at the seat of the ligature was healthy; every thing progressed favorably, and the ligature dropped off on the twenty-eighth day after the operation. Soon after the application of the ligature the dense character of the tissues of the leg became much abated; the spine of the tibia could be traced by the finger, which could not be done previously; the folds of dense tissues around and above the ankle became soft and diminished; the flexion and extension of the joint could be accomplished.

The following measurements were taken on the 26th December, fourteen days after the operation, showing, by reference to the first measurements, that the limb had considerably diminished: Right side, diseased, around the middle of the thigh, 19½ inches; around, above the knee, 15½ inches; under the knee, 12¾ inches; around the middle of the calf, 12½ inches; around the ankle, 10¾ inches; around the instep, 10¼ inches; around the toes, 9 inches.

This patient now walks about with facility. After walking for a length of time without a bandage, the limb becomes somewhat enlarged; but the tissues are now soft and compressible, and the limb is gradually regaining its natural condition.

The next case which came under my observation is of interest, as both of the lower limbs were affected, and both femoral arteries were tied.

Catherine Punch, native of Ireland, aged 26 years, unmarried, entered the hospital on the 29th of October, 1857, for elephantiasis of both legs.

For several years past she had suffered from pain in the legs, especially in the right one. About three years since, her legs began to enlarge, and they have slowly increased up to the present time.

The right limb being most diseased, the femoral artery was tied on the 30th January, 1858: the artery was healthy, and the ligature came away on the twenty-third day after the operation. After the application of the ligature the tissues of the limb soon became softer and more natural, and the size also gradually diminished.

The patient was so much satisfied with the result of the first operation that she insisted upon having the artery tied upon the left side. On the 17th April, two months and a half after the first ligature had been applied, the left femoral artery was tied. Only eleven days have elapsed since the operation, yet there is a decided amelioration in the condition of the limb, both as regards the diminished size and the induration of the tissues.



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ELEPHANTIASIS ARABUM TREATED BY LIGATURE OF BOTH COMMON CAROTID ARTERIES.

Fig. I.

Represents the patient before the operations and shows the Hypertrophied and diseased condition of the tissues of the head, face & neck..

Fig. II

Represents the same patient eight years after the ligature of the Common Carotid arteries, and the subsequent changes effected in the diseased tissues

ELEPHANTIASIS ARABUM

OF THE

HEAD, FACE, AND NECK:

TREATED BY

LIGATURE OF THE COMMON CAROTID ARTERY ON BOTH SIDES.

Pathological combinations exist at times in certain morbid growths, involving the cutaneous and immediate subcutaneous tissues, which render it somewhat difficult to give them a definite position according to conventional classification. Certain enlargements of the limbs, scrotum, labia majora, face, etc., usually accompanied by hypertrophy of the skin, distinct from phlegmon, from œdema, and from bloody tumors, have long been, and are still, described or designated under the name of Elephantiasis Arabica or Arabum.

Patients affected with Elephantiasis Græcorum have sometimes, with the predominant tubercular characteristics of this affection, presented not only œdema of the lower limbs, which is common, but the true hard and bulky enlargement of Arabian elephantiasis also.

We are informed by Pliny that the former malady was indigenous to Egypt—"*Ægypte peculiare hoc malum*"—but we learn from other Latin and Greek authors, as well as from the writings of more recent observers—among whom may be mentioned Larrey, Heberden, Robinson, Adams, and Rayer—that the disease has been met with in most parts of the globe. It is undoubtedly very rare in the United States, where but few cases, as far as I am aware, have been seen.

Greek elephantiasis (leontiasis of the ancients) is a tuberculous disease

affecting especially the skin, the mouth, and the nasal fossæ, and the organs of voice and respiration. In Elephantiasis Arabum the skin is generally not primarily affected; the different layers, however, soon become hypertrophied and pachydermatous, while the other tissues, for example, of the lower limbs or neck, become changed in structure, intumescent, hard, and at times loaded more or less with serosity.

In the former, obstinate ulcerations are likely to occur, with intercurrent disease of some of the internal parenchymatous and digestive organs, generally leading early to a fatal result; while in the latter the disease is of slower growth, more tardy in its progress, less liable to be complicated with ulcerations or internal disease, and rarely implicating the nares, mouth, and respiratory apparatus. Hence it will be observed that while the two forms of the disease are different, there are sometimes found complicated structures in diseased masses, presenting various characteristics, and requiring different appellations when subjected to the rules of artificial classification. From this probably has arisen the confused descriptions given by the ancient Latin, Greek, and Arabic authors of certain morbid growths.

The case described below, and carefully represented in the accompanying plates, was partially of this mixed character. At the commencement the tubercular appearance seemed to indicate traits allied to Elephantiasis Græcorum, but the characteristic signs or manifestations peculiar to Elephantiasis Arabum were throughout its progress so predominant that it can only be considered properly as a case of that disease.*

Case.—Mrs. Phebe B—— was born in New Jersey, in the year 1814, of healthy parents in good circumstances, who were also natives of the same State. Her father died of disease of the kidneys at the age of 80, never having had any morbid growth; her mother also enjoyed good health until near the period of her death, which occurred at the age of 85. She has three sisters and two brothers, who have been free from unusual disease, and are still living and healthy.

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* Originally published in the *American Journal of the Medical Sciences* for July, 1867. Upon revision, it is evident that the preponderating characteristics of this case are such as to give it the type of Elephantiasis Arabum. See early numbers of the journal of *Cutaneous Medicine and Diseases of the Skin*, by Erasmus Wilson.

Until the age of 28, Mrs. B—— had always been free from bad health, and, in fact, was supposed to have an excellent constitution. Her complexion was fresh and healthy. About this time (1844), without any special cause, the disease began to develop itself below the corner of the mouth, on the right side of the face, in the form of a small pimple not larger than a grain of hemp-seed, and presenting on its surface a small whitish speck, like the secretion of a cutaneous follicle. This, when pricked or squeezed, exuded a small quantity of thin, bloody fluid. The pimple remained stationary for some months, and then began to enlarge, assuming the shape and appearance of a discolored, smooth, watery excrescence. This soon increased to the size of a filbert, and was removed by the knife, by a medical practitioner of the district, under the supposition that it was an encysted tumor. After this slight operation the bleeding was unusually profuse; caustic was applied upon the bleeding surface.

In about a year after the first operation, in close proximity to the cicatrix, a similar growth began to make its appearance, and in about six months had reached the same size. This was also removed, and was again attended by unusual hemorrhage. The adjoining tissues remained normal for seven or eight months, but were again attacked by another mammillated growth, which became more irregular on the surface, and of a reddish hue, attaining the size of a walnut in about two years. Excision was again resorted to for the third time, the bleeding, as before, being very profuse.

At this stage of the disease the patient, who had not been medicated before, began to take various medicines internally, such as sarsaparilla, iodine, iron, etc. A special "cancer doctor" was also consulted, who prescribed some unknown compound without benefit. The disease was not abated by constitutional treatment, but continued to spread, the tubercular elevations becoming multiplied, and extending from the original focus of the disease in various directions. The patient now visited New York, and consulted an eminent physician of that city, who prescribed internal and external medication, baths, etc. She continued under medical treatment, with some improvement of the general health.

She had now been suffering for ten years, from 1844 to 1854, without

receiving any material benefit from treatment in impeding the progress of her disease. In the course of the extension of the disease the parts were always affected by increase of temperature, by pricking, burning, and painful sensations, and discoloration of the surface.

From the year 1854 up to the time I was consulted, in March, 1858, the morbid growth assumed a more diffusive shape, and continued gradually to enlarge, the mammillated tubercles continuing to be evolved in increased numbers and size, invading the organs of sense, and giving to the countenance a most hideous appearance. In fact, the face had now assumed the aspect which is characteristic of Elephantiasis Græcorum, or the leontiasis of some authors. The tissues, however, under and around the chin and lower jaw, and on the neck, had assumed the hard, pachydermatous nature and appearance of Elephantiasis Arabum.

By reference to the accompanying plate it will be seen that the disease had become developed into huge proportions, and that the face, head, and neck presented a misshapen, bulky, deformed mass. (*Vide* Plate No. II.)

On the 18th November, 1858, Mrs. B——, when first seen by me, was in the following condition: The face, head, and upper part of the neck were enlarged to a frightful extent, sanctioning, by the character of the deformity, the term of leontiasis, used by the ancients to designate the disease. The morbid mass extended from an irregular transverse line a short distance above the superciliary ridges downward to the neck, as far as another line drawn across about an inch below the cricoid cartilage, and running backward as far as the posterior margin of the sterno-mastoid muscle. Another line drawn upward from the posterior extremity of the last, and passing upward behind and above the mastoid process, formed the boundary of the main mass in this direction; while, anteriorly, the disease passed over the mesian line, and occupied in a similar manner the other side of the neck, and three-fourths of the other side of the face. The morbid growth was more developed on the right side than on the left. On the back of the neck, as low down as the sixth cervical vertebra, the skin was wrinkled, irregular, discolored, scaly, and studded with flattened elevations rising slightly above the level of the skin, which was also similarly affected on the supraclavicular

regions and the upper part of the sternum. The hairy scalp was in the same condition, more particularly on the right side of the head.

The color of the skin, or complexion, was a dark, dingy maroon or purplish hue in the region of the face; on the neck the color was dull and leaden, without any reddish tinge. There was a general sensation of harshness imparted to the touch in passing the hand over the mass.

The cutaneous tissues on the lower part of the forehead were discolored, thickened, and furrowed with wrinkles. On the face the tissues were somewhat semi-elastic and boggy, and softer than on the region of the neck; here the tissues were positively pachydermatous and dense, like Elephantiasis Arabum.

The scalp had become partially despoiled of hair from the disease; some of the hair also of the eyebrows had fallen out, and part of the eyelashes were lost. The eyelids were swollen, and so much hypertrophied as to project beyond the level of the forehead, and completely occlude the ocular fissure. Vision on the right side was entirely obstructed, and the power of elevating the eyelid was altogether lost. The nose was enlarged, irregular on the surface, and pushed toward the left side, where the tissues were not quite as tumid. The nostrils were blocked up and misshapen. There was no sense of smell. The *alæ nasi* were uneven and knobby, and merged into the rough and dense mass of the cheeks and side of the face. The cheeks, particularly on the right side, were much swollen, and elevated beyond the natural level, rough, and deeply furrowed.

The lips were much hypertrophied, thickened, and deformed, and the mouth so occluded as to scarcely admit of the passage of a teaspoon into the cavity. The upper lip had an elongated appearance, rough, but not tuberculated, while the lower was beset with a cluster of mammillated elevations. Nourishment was taken with great difficulty, and mastication was almost impossible; taste imperfect.

The ears, particularly the right, were much enlarged and tumefied. The right ear stuck out or projected from the head; the *concha*, *tragus*, *antitragus*, and *lobule* presenting one large, irregular, furrowed mass of a dusky reddish hue. The *meatus externus*, on this side, was completely oblit-

erated. Sounds were almost inaudible. The chin and neck presented a huge hypertrophied mass, extending to within a short distance of the sternum and clavicle. The tissues here were harder and denser than at other parts, rising above the level of the natural surface about four inches, and studded with numerous tubercular and mammillated elevations.

The integuments of the trunk and extremities, with the exception of that on the sternal and supraclavicular regions, did not present any manifestation of disease.

The general health of the patient was not good. She had sleepless nights, and had to be bolstered up in bed on account of the difficulty of breathing, arising from the pressure of the diseased mass in the neck upon the trachea. She had but little appetite, and was frequently feverish. The menstrual function was regular.

The patient, thus suffering and disfigured, with the disease progressing at a rapid rate, was willing to submit to any treatment which promised amelioration or relief. Therapeutic means the most approved had been unavailing, and it was futile to repeat them. It occurred to me that the morbid nutrition of the parts might be modified in a salutary manner by intercepting the main arterial supply, and that the perverted vitality or morbid action of the organic nerves supplying the capillaries would in this manner be best reached and impressed.

I was also inclined to believe that in this instance the capillaries and smaller vessels were at fault by positive change of structure, and that at some portions of the mass the smaller arteries and veins were diseased and enlarged, as in cases of accidental erectile tissue. With these views, I proposed to put a ligature on the common carotid artery of one side, and if necessary, after a proper interval, to secure the arterial trunk on the opposite side.

Operation.—The operation of tying the right common carotid artery was performed on the 28th November, 1858. On account of the general thickening of the tissues, the usual relative points of guidance were not visible, and could not be made available in the first steps of the operation. The assistants being suitably arranged, and the patient placed on the table

and put under the influence of chloroform, the head was turned slightly toward the left side. The external incision was then made through the dense structures, following the direction of a line drawn from the anterior part of the mastoid process to the internal extremity of the clavicle, commencing about an inch above the level of the upper border of the thyroid cartilage, and extending downward for the distance of three inches and a half. The first incision divided the skin and platysma myoides, both of which were blended together, hard, and vascular. The muscular fibres of the platysma were changed and effaced. The next incision was carried deeply, two and a half inches, through dense infiltrated and vascular cellular tissue, and exposed the anterior border of the sterno-mastoid muscle. Beneath this border the deep cervical fascia, and the sheath of the vessels formed by it, were then laid bare. The pulsations of the artery could now be distinctly felt, and the internal jugular vein was seen bulging up, swollen with blood at each inspiration. By means of curved copper spatulæ, the lips of the wound were kept apart, and the hemorrhage, which had been profuse, was stopped by securing the bleeding vessels. The omo-hyoid muscle crossing the large vessels, and the loop of the hypoglossal nerve resting on the anterior surface of the sheath, could now be seen. The muscle was hooked upward, and the deep jugular, which partially overlapped the artery, was gently pressed aside. The sheath of the vessels was now cautiously opened, and the artery separated from the vein to a very small extent by using the director very delicately. The vessel was now secured by passing the aneurism needle, armed with the ligature, under the artery, from without inward, taking care not to include the pneumogastric nerve.

During the different steps of the operation much difficulty was encountered by the deep position of the artery. The hemorrhage was exceedingly profuse, showing that the smaller vessels ramifying through the hypertrophied structure were unusually active, enlarged, and numerous. These, however, were readily secured. The ligature came away from the main artery on the twenty-eighth day.

The operation was followed in a few minutes by a perceptible and general shrinking of the enlarged structures, and a diminution of the density

of the mass; the color became less deep, and the temperature was considerably lower. In two weeks the change became so great that the patient could see and hear; the eyelids were less tense, and a part of the globe of the eye could be seen. The wall of the obstructed *meatus auditorius externus* had shrunk, and again become tubular and permeable, so as to admit the undulations of air upon the tympanum; finally, the general sensibility had become more natural. Although the ligature came away on the twenty-eighth day, the patient was not allowed to leave her bed until the thirty-first day, after which she was permitted to sit up and walk about.

Some three months after the ligature had been placed upon the artery, the shrinking of the mass became stationary, and there was a slight extension of discoloration, or encroachment upon the sound tissues from some portions of the margin.

In June, 1859 (six months after the operation), the patient again paid me a visit. The process of diminution of the disease being now apparently passive, I thought it expedient to tie the common carotid trunk on the other side. This was done on the 14th of June, and the ligature separated again on the twenty-eighth day. The operation was accomplished with less difficulty than on the previous occasion, on account of the tissues on the left side being less hypertrophied, and of the artery not being so deeply covered. The effect of the second ligature was followed by the same general phenomena as were observed after the first. The tumefied parts shrunk farther, the color became paler, and the temperature depressed.

Four months after this (October, 1859), the patient called upon me. Her general health was improved, and the tissues of the face were getting more mobile. At this visit I injected, with one of Pravàz's syringes, about fifteen drops of the solution of perchloride of iron into the still enlarged tragus of the ear. The fluid entered the tissues freely, causing pain, discoloration, and hardening of the part. An eschar was formed, which was soon thrown off, leaving a healthy granulating surface, which healed well. The enlargement was diminished and the appearance improved by this procedure.

In October, 1860, the curative process was apparently stationary or passive. The mammillated tubercles on the back of the neck had now

become shrivelled and scarcely perceptible, leaving a surface somewhat softer, and but slightly wrinkled or discolored. Partly from the shrinking of the surrounding tissues, and partly from increased growth, several nipple-like tubercles on the lower portion of the cheek on the right side had assumed the shape and size of a hen's egg. A strong double ligature was passed through this part of the cheek, with the intention of strangulating the projection at its base. This was partially effected in about a week, and the remaining pedicle was divided by the knife. A large granulating surface was thus left, which healed readily, leaving a white solid cicatrix on the natural level of the cheek.

Saw the patient again in June, 1861. During the interval since her last visit (October, 1859), her general condition had been good. The organs of the external senses were resuming their functions more naturally. A portion of the mass, about three inches long and two wide, situated under the jaw, and extending backward toward the angle, although much contracted, still was slow in decreasing in size. This was removed by excision to the natural level. The exsected part proved to be very vascular and spongy, resembling the erectile tissue of aneurism by anastomosis. The wound was dressed to heal by second intention, and cicatrized healthily in six or seven weeks. In September following, a small portion of the lobule of the right ear was removed, which also cicatrized without difficulty. In May, 1862, Mrs. B—— came again to the city for consultation, on account of an attack of acute conjunctivitis of both eyes. She soon recovered from this attack, and returned home. She was not put under any medicinal treatment, as the general health was good, and the curative process of diminution was progressing favorably and gradually.

From May, 1862, until November, 1865, the patient continued in good condition. In general, the skin of the face, head, and neck, during this interval, became softer, and the sensibility of the surface more normal; a part of the end of the nose and of the upper lip puffed up and enlarged. Free scarifications were used, which were followed by profuse flow of blood and serum. The incisions healed kindly, with contraction of the parts and marked improvement in appearance.

Toward January, 1866, an elevation made its appearance again on the upper lip. This was excised, and the parts returned to their more natural proportions. Nine months after this a puffy, mammillated eminence sprung from the tip of the nose larger than an almond. This was excised from the cartilage, and the lips of the cut partly approximated by two metallic sutures. The cicatrization went on favorably, leaving the end of the nose but little disfigured.

December, 1866.—About eight years have now elapsed since the first ligature was applied upon the trunk of the common carotid. With the exception of occasional indisposition, generally arising from the effects of cold, Mrs. B—— has enjoyed a very tolerable condition of health. At present all the functions are well performed, physical and mental. She is in good spirits, and is a useful person in the household of which she is a member.

The vision is good; the eyelids are free and open, and are under the control of the orbicularis and levator palpebrarum; the hearing is acute, the *meatus auditorius externus* being perfectly free and open. The senses of smell and of taste are now perfect. The general sensibility, dull and obscure before the ligature of the carotids, is now normal, and, as the patient expresses it, the surface feels to her like the natural flesh. The feeling of excessive heat in the parts has also subsided. The color of the skin is much less deep. The general shrinking of the mass following the ligature upon the carotids has changed the hideous and bulky deformity into a physiognomy of much less disfiguring proportions. (*Vide* Plate No. II., Fig. 2.)

Mrs. B—— now sleeps in bed with complete comfort, which she was before prevented from doing by the bulkiness of the disease in the region of the neck. She can now move her eyelids, masticate freely, and rotate the head upon the neck without impediment.

The nasal and buccal cavities are healthy. Occasionally tubercular elevations have arisen from the tissues originally the seat of disease before the operations. These have been amenable to excision and injections, which have been followed by healthy cicatrization.

There is at present no disposition in the disease to extend, but, on the contrary, a marked tendency toward further progressive diminution and

shrinking in those parts where the level of the original surface is not attained.

The portions of the diseased mass which were excised exhibited pathological changes of a marked character, as was at first diagnosticated. The tissues principally involved in the disease were the dermoid, the subcutaneous adipo-cellular layer, and the vascular. On the face, where the tubercular character of the disease was most manifest, the skin was covered with cuticle in the form of slight squamæ, under which the corion assumed a reddish tint. Numerous white specks were disseminated over the irregular surface, and these appeared to be the augmented secretion from the enlarged sebaceous follicles. The dermoid tissue proper was not much thickened on the nipple-like projections; the subcutaneous layer of cellular tissue was hypertrophied, and the mesh-work expanded and infiltrated with oily serum and lymph; the vascular tissues, arteries, and veins ramifying through this morbid structure were abnormally developed and active; finally, the tubercular elevations were formed principally from the adipo-cellular layer thus transformed.

The portion of the diseased structure excised from the neck under the jaw was entirely different in character. The surface here was leaden, scaly, rough, and hard, and the skin thickened, as in Elephantiasis Arabum. The cellular tissue was much hypertrophied, dense, infiltrated, and vascular. In some parts the arteries and veins were so developed as to assume the character of what is termed by Cruveilhier accidental erectile tissue—"*tissu érectile accidentel.*" The microscope revealed nothing of importance.

The functions of the brain are performed as well as at any period of her life. The memory is not in the slightest degree impaired, and the other faculties of the mind are equally undisturbed. In fact, there has been no alteration mentally from the operations on the common carotids.

NEW YORK, *March 2d*, 1867.

The publication of the first operation for the treatment of Elephantiasis Arabum by ligature of the principal artery, by which the diseased structures are supplied with blood, was soon followed by similar operations in different countries. I subjoin a statistical table of cases as collected by Professor Wernher, of Giessen, and published by him in an elaborate article on this subject.* After alluding to the large number of observations and dissertations which have been written on the pathology and therapeutics of this malady, he proceeds as follows:

"Wir können aber nicht sagen, dass der Werth dieses Beobachtungsmaterials der Menge und dem Umfange desselben entspräche. Wir sind immer noch in Controversen über die wesentliche Ursache dieser Krankheit und wo ihre Anfänge zu suchen sind. Zufolge dessen hat man Vieles, was sich nur in den Folgezuständen gleicht, der Anschwellung der Glieder, zusammengeworfen: Oedeme, Sarkome (Hecker), Hypertrophien bei Varicositäten der Venen, chronisch entzündliche Indurationen—der immer noch fortdauernden Verwirrung und Verwechslung mit der Elephantiasis graecorum und Lepra nicht zu gedenken. Manches, was als völlig ausgemacht gilt, ist durchaus unerwiesen und wahrscheinlich nicht begründet, so die sehr allgemein angenommene entzündliche Verschliessung der Lymphgefässe oder deren Drüsen als allgemeine und erste Ursache der Lymphstauung.

"Ebenso wenig vorgerückt sind wir in Bezug auf eine rationelle und wirksame Behandlung. Bis jetzt ist es kaum gelungen, diese Krankheit durch irgend eine arzneiliche Behandlung in ihrem Verlaufe aufzuhalten oder gar zu beseitigen. Wenn von Einigen, welche augenscheinlich hierin Herdy folgen, die Hoffnung ausgesprochen worden ist, die Elephantiasis bei ihrer ersten Entstehung wirksam behandeln zu können, so ist dieser Behauptung entgegen zu halten, dass erst die fortgesetzte Beobachtung lehren kann, ob erysipelatöse Anfälle zu einer dauernden Elephantiasis und nicht blos zu einer vorübergehenden ödematösen Schwellung führen. In unseren nördlichen Klimaten insbesondere, in welchen die Krankheit relativ selten unter fieberhaften, entzündlichen Erscheinungen auftritt, und so selten ist, dass man nicht in jeder beginnenden Schwellung der Glieder eine beginnende Elephantiasis vermuthen darf, muss die Zuversicht auf eine glückliche Behandlung der Prodromalerscheinungen noch viel geringer sein, als da, wo ihre endemische Verbreitung die richtige Deutung von Anfangssymptomen erleichtert und wahrscheinlicher macht. Jeder allgemeinen

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* *Deutsche Zeitschrift für Chirurgie*, Fifth Vol., Fourth and Fifth (Double) Number. Leipsic (Vogel), 1875. Issued June 4th, 1875. Art. XVI.

Behandlung zum Trotze führt die Krankheit, ihrem natürlichen Verlaufe nach, unausbleiblich zu chronischem Siechthume und nach jahrelangem, oft entsetzlichen Leiden zum Tode. Was früher von chirurgischen Hülfsmitteln versucht worden war, die Druckbinde, die horizontale Lage, Scarificationen, etc., hat mehr nur die Folgezustände, als die Krankheit selbst in ihren wesentlichen Ursachen getroffen und blieb meistens ohne dauernden Erfolg. Die von Dieffenbach angeregten Versuche, durch wiederholte Excisionen langer Hautstreifen und der Narben derselben, pachydermische Schwellungen zurückzubilden, haben in den Händen Anderer nicht den Erfolg gehabt, welchen Lebert (Abhandlungen aus dem Gebiete der praktischen Chirurgie) von ihnen rühmt, und die Methode ist überhaupt, ausser von Dieffenbach, nur wenig versucht worden.

"....So blieb denn nichts übrig, als den Kranken mit einigen palliativen Mitteln gegen Nebenzufälle zu versehen, oder, wenn die Beschwerden unerträglich wurden, sich zu Exstirpationen und Amputationen zu entschliessen.

"Bei dieser wenig befriedigenden Lage der Sache wurde der erste Erfolg, welchen Carnochan im Jahre 1852 durch Unterbindung der Hauptarterie des geschwollenen Gliedes erhalten hatte, freudig begrüsst. Der Gedanke, auf diese Weise Hülfe zu schaffen, glich den glücklichen Inspirationen, durch welche so oft schon eine in Dunkel gehüllte, aber fast selbstverständliche Wahrheit, wie durch einen Lichtblitz mit einem Male aufgehellt, und Allen, die wie mit Blindheit geschlagen an ihr vorübergegangen waren, offen vor Augen gelegt wurde. War auch die Voraussetzung,* von welcher Carnochan ausgegangen, nämlich dass die Arterie erweitert sei, irrig, oder doch nur in wenigen Fällen zutreffend (Chelius, Heidelberger Annalen, glaubte ebenfalls schon die Cruralarterie erweitert gefunden zu haben), und ohne Bedeutung für die Erklärung der Krankheitsgenese, so schien doch der Erfolg unzweifelhaft und auf dem glücklichen rationellen Gedanken zu beruhen, das gestörte Gleichgewicht zwischen der Zufuhr, der Anhäufung und Verwendung der Ernährungssäfte durch Verminderung der Zufuhr auszugleichen."

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* The enlargement of the artery is mentioned in the text as a fact merely, not as a source of the disease.

NOTE 1.—Bauer's case as reported in the table (No. 17) is reckoned as one which had a relapse. I had an opportunity to see this person in 1874, five years after the ligation of the femoral artery below the art. profunda. At that time the leg and thigh were enlarged, but after reaching a certain point the size of the limb remained stationary, and continued smaller and softer than it had been prior to the operation. This man could walk about quite well. This case was one of great extent, involving the entire limb as high up as Poupart's ligament. Professor Syme, of Edinburgh, had removed the scrotum for elephantiasis. The ligature of the external iliac artery was indicated in a case of such magnitude.

NOTE 2.—I am informed that this patient (No. 2 in the table) entered the Pennsylvania Hospital mainly for the breaking out again of the extensive ulcerations of the leg.

STATISTICAL TABLE OF CASES OF ELEPHANTIASIS ARABUM,

TREATED BY LIGATURE OF THE MAIN ARTERY,

AS PRESENTED BY PROFESSOR WERNHER

IN THE "DEUTSCHE ZEITSCHRIFT FÜR CHIRURGIE," JUNE, 1875.

No.	Author. Year.	Sex. Age. Side of the Body.	General State of Health before the Operation.	Symptoms. Duration of the Disease.	Treatment.	Accidents after Ligation.	Immediate Success.	Later Results.
1	Carnochan. New York Jrn. of Med., 1852. Contributions, etc., 1852.	M. 27 years. Aachen. r.	General state of health good. Repeated attacks of intermittent fever precede the œdema.	The whole leg is swollen for 6 months previously. Rest, horizontal position, and wrapping the limb up, tried without success for 3 months.	Lig. of a. femoralis close under the profunda. The art. has the calibre of the iliaca.	The ligature falls off on the 11th day. The il. ext. gets ligated on account of secondary hemorrhage. Hemorrhage continues. Tourniq. applied to the central end of the artery does not suffice; a second, applied to the periph., stops the hemorrhage.	Cure after 3 months.	The continuation of the success is confirmed 17 months later.
2	Carnochan. Contribut., etc., 1858.	M. 58 years. Italian. l.	Feeble, cachectic constitution.	Extends over the leg for 6 years; numerous ulcers. Inability to walk.	Ligation of the arter. fem. March 23, 1857.	The art. appears normal. The ligature comes off on the 34th day.	The swelling of the leg diminishes rapidly, the ulcers heal. At the time of dismissal, after 3 months, nearly natural circumference; some lameness.	Relapse after 14 months. Admitted to Pennsyl. Hospital, and discharged not cured. [See Note 2, page 51.]
3	Carnochan. Ibid., 1858.	F. 25 years. Ireland. r.		Exists for 5 years. Grown up to the middle of the thigh. Difference of circumference on the calf of the leg, $3\frac{1}{2}''$. Thick tumors of the skin; immovable ankle-joint.	Lig. of a. fem. in trigon. Scarpæ. Lig. becomes separated on the 28th day.		After 1 month the circumference has diminished by 1 inch, the skin has become soft.	Discharged after $1\frac{1}{2}$ mo. The patient can walk with ease. But the leg becomes œdematous when no bandage is worn.
4	Carnochan. Ibid., 1858.	F. 28 years. Ireland. Both extremities.	Pains precede the swelling for several years.	Both extremities are swollen, the right more than the left, up to the thigh.	Lig. of art. fem. dext. Separation of ligature on the 23d day; that of the left later.	Skin becomes soft rapidly and diminishes. Patient insists on lig. of second art.	Published on the 11th day after the second ligature. Information of a later date is wanting.	

No.	Author. Year.	Sex. Age. Side of the Body.	General State of Health before the Operation.	Symptoms. Duration of the Disease.	Treatment.	Accidents after Ligation.	Immediate Success.	Later Results.
5	Statham. Letter to Erichsen.	M. Middle age.		Hard œdema of the leg.	Lig. of art. tib. antic. at the middle third.		Circumference of leg gets almost normal.	Later information is wanting.
6	Ogier. Amer. Journ. of Med. Sc., 1860.	M. Negro. 26 years.		Existing for 5 years; enormous swelling of leg and foot.	Lig. of art. femor.		Already on the following day the swelling is considerably less. Cure.	Affirmed after 3 months.
7	Butcher. Operative and Conservative Surgery, 1865. Dublin Quarterly Journal, 1863.	F. 44 years. Ireland. r.		Existing for 18 years. The difference of the circumference amounts to 8″. The sufferings cause the patient to desire an amputation. Pains by day and night. Increasing weight, repeated painful attacks with increased swelling. Only short intervals of rest. The color of the skin is dark, the calves are specially swollen, the toes are ulcerated.	Lig. of a. fem. 1½″ below lig. Poupart. Separation of ligature on the 31st day. Compression bandage; salve containing iodine.		Cure.	Affirmed after 18 months and after 4 years.
8	Richard. Gaz. des hôpit., 1864. A summary of surgical operations performed in the Bristol Royal Infirmary. British Med. Journ., 1869. June.	F. 28 years. French. l.	Menstruated since the 16th year. Good health, without previous disease.	Painless, gradual swelling, extends rapidly to the thigh. Walking very difficult. Periodic swellings preceded inflammatory attacks of the lymphatics. Cups draw a milky fluid mixed with blood; sensation of cold alternating with burning heat. Skin indurated, cannot be folded, color not changed; beginning swelling of nates and skin of the abdomen.	Lig. of art. femor. beneath the descent of the profunda.		Swelling and tension diminish from the 1st day. Diminution of circumference about 5 cen. Methodical compression bandage, with flannel and gutta-percha roller, can be tolerated only for 5 to 8 hours in the day.	1½ years after the operation incomplete cure. The lower leg has diminished the most. On the knee the parts reassume normal flaccidity. The leg is hardly thicker than the sound one. The pulse cannot be felt on the malleol., although collateral circulation is restored.
9	Fayrer. Edinb. Medic. Journ., 1865.	M. 30 years. Hindu. r.		Leg for 7 years. Periodic attacks of fever characterize the progress of the disease.	Lig. of art. fem.; separated on the 17th day.		The swelling decreased rapidly.	Death thro' pyæmia on the 18th day, sequence of hospital influences.
10	Same. Wilson Journal of Cutaneous Diseases.				Lig. of art. fem.			Death.

No.	Author. Year.	Sex. Age. Side of the Body.	General State of Health before the Operation.	Symptoms. Duration of the Disease.	Treatment.	Accidents after Ligation.	Immediate Success.	Later Results.
11	Bryant. A case of Elephantiasis Arabum. London Med. Chirg. Trans., V. XLIX., p. 175. Lancet, 1866.	F. 25 years. Wals.	Good health. Ten years ago light scarlatina. During the convalescence the leg from the calf upward begins to swell. Twice very profuse exudations of lymph, with transitory amelioration.	Since 2 years rapid increase of the swelling, without pain or feeling sick. Supposed cause, lying in a moist bed. Always perfectly painless. Pressure by bandage. Quiet and application of cold tried in vain. Ulcers in the depth of a fold of skin, with discharge of black blood. Swelling hard, brown, sharply defined above the ankle.	Planum inclinatum. The swelling diminishes only in the first seven days; no more after that. Lig. of iliaca ex., artificial application of warmth, elevated position.	Artery of normal condition.	Decrease of circumference on the next day about 1″. Restitution of warmth on the 2d day. After 3 weeks circumference diminished about 6″. The brown color and skin disappeared almost completely after 3 months.	Recovery still maintained after 8 mos.
12	Alcock. Lancet, 1866, p. 310–314.	M. 33 years.	Since 2 years, on lower part of leg, in the circumference of a wound from a bite and burn. Whether really elephantiasis?	Strong workman —miner. Numerous ulcers. Swelling of the leg when they healed. Swelling disappears when lying in bed, returns after work. Vessels cannot be felt. Artery normal. Bandages, rest, without success. Difference in circumference about 3″.	Lig. of art. fem. at the lower third.			After 3 mos. the cure appears to succeed. Diminution of swelling still progressing; amounts to 1″. Ulcer presents a healthier appearance.
13	Buchanan. Med. Times and Gazette. Clinical Lectures, Glasgow. Medic. Jour., 1866.	F. 17 years. r.	Healthy.	The whole extremity thickened since 3 years. Treatment in vain.	Lig. of art. iliaca ext. Lig. separates on the 13th day.		After the 9th day decrease by some lines. Discharged as cured, with diminution of circumference from 3″ to 8″.	Still maintained after 3 months. Relapse after 11 months.
14	Quirel. Ligat. de la fém. dans un cas d'Éléph. Gaz. hebd. de M., 1862.	M. r.	Gen'l health good.	Since 5 years every kind of treatment in vain.	Lig. of art. fem.		Rapid diminution of circumference.	Complete relapse after 1 year.
15	Sympson. St. Barthol. Hosp. Rep., V. IV., 1866.	F. 41 years. l.	Exists since 16½ years.	Application of bandages continued for 1 month without success.	Lig. of art. fem. 4 fingers' width beneath lig. Poupart.		After 3½ mos. the circumference of the calf of the leg decreased by 3½ inches.	Affirmed 3 months later.
16	Pöndén. Upsal. Lakeforen. Jahresbericht von Virch.-Hirsc., IV. Jahrg., Bd. 2.			Elephantiasis of right arm and hand.	Lig. of art. brachialis.		Swelling diminished considerably already on the next day. Continual improvement.	Later information wanting.

No.	Author. Year.	Sex. Age. Side of the Body.	General State of Health before the Operation.	Symptoms. Duration of the Disease.	Treatment.	Accidents after Ligation.	Immediate Success.	Later Results.
17	Bauer. An aggravated case of Eleph. Arab. relieved by ligation of the main artery and elevation of the affected member. 1869.	M. l.	Syme had extirpated the scrotum 3 years previously, and witnessed diminution of swelling during the process of cicatrization; later the swelling had increased continuously.	Violent pains at the ankle-joint make compression bandages inapplicable.	Lig. of art. femor. close under the descent of the profunda. Application of starch bandage. Tight stockings.		Swelling reduced down to a small remnant.	Relapse begins after 3 months, and is complete after 10 months. [See Note 1, page 51.]
18	Bryk. Zur Casuistik der Eleph. Oestr. Med. Ztg., 1869.			Compression bandage since 7 weeks, with only partial success. At last stationary.	Lig. of art. femor. beneath lig. Poupart.		Reduction of swelling down to a small difference.	Relapse begins after 3 months; complete after 20 months.
19	Same.	F. 20½ y'rs. r.	Insufficiency of mitral valve since 4 years; frequent attacks of erysipelas since 4 years.	Violent pains at ankle-joint make application of compression bandages inapplicable. Injections of chlor. of sod. produce abscesses.	Ligation of art. femor. close beneath Poup. ligament.		Complete reduction of swelling. Normal condition of skin.	
20	Same.	l.	Elevated position for several years; little diminution of swelling.	Formation of abscess.	Lig. of art. fem. After half a year, in order to promote continuation of healing, compression of art. popl. thr' Bouley's compressorium continued for 3 months daily from 1 to 1½ hours.		Reduction of swelling, and beginning cicatrization of ulcer. Continued compression causes gangrene and reopening of the ulcer.	Amputation anticipated.
21	Carnochan. Amer. Jour. of Med. Sc.	F. 42 years.	Healthy up to 28th year, then warty excrescences around the mouth. Extirpated 3 times. Relapse.	Since 14 years knotty excrescences upon both sides of the face. The thickened eyelids cannot be separated one from another; seeing, therefore, impossible. Nostrils closed; sense of smell destroyed. Passage of the right ear closed. Mouth so contracted that hardly a spoon can be introduced.	Lig. of carot. dextr. difficult on account of thickening of the skin. Lig. separated on the 28th day. Six months later, ligation of carotis sinistra. Some knots excised.		Pain little. The thickening of the skin disappears; it gets paler and cooler. Fourteen days after 1st operation the woman can hear and see. No further reduction after 3 months. No cerebral disturbance.	Cure confirmed after 8 years.

No.	Author. Year.	Sex. Age. Side of the Body.	General State of Health before the Operation.	Symptoms. Duration of the Disease.	Treatment.	Accidents after Ligation.	Immediate Success.	Later Results.
22	Simon. Klin. Chir. d. Nieren und bei Fischer, Virch. Arch., Bd. 46.	F. 20 years. Both sides.	On the left side since 4 years; since 1 year on the right side.	Experimented with iodine and pressure bandage for 2 months without permanent success.	Lig. of iliaca externa sinistra.	Secondary hemorrhage. Imminent danger to life during the operation.	Decrease of circumference in the operated and not operated side, of the fever, and of the bodily circumference in general.	Relapse after 8 months; and after 2 years greater swelling than before. Injection of iodine causes ulceration.
23	Baum. Bei Fischer, Virch. Arch., Bd. 46.	M. 31 years. l.	Preceded by erysipelas, ulcers, and pain. The whole limb swollen since 12 years.	Almost circular ulcer on lower leg. Pulse can be felt only very indistinctly. Difference in circumference 5 and 10 cm.	Lig. of art. femor. beneath Poupart's ligament. Profuse hemorrhage.		The circumference of the limb does not diminish. But the ulcer is almost completely healed after 3 mos. Abscess upon the leg. Patient begins to walk about.	
24	Baum. Ibid.	F. 38 years. l.	Miserable, haggard condition of body. Many deep sinuses and ulcers.	Spreading of the elephan. beyond the lower leg. Vesicular eruptions on lower leg 1 to 2 times in the year.	Lig. of art. femor. beneath profunda. Ligature separated on the 14th day.		Already on the 22d day gangrene begins, with unusual weakness and great pains. Amputat. above the ankle-joint.	After 2 mos. the wound caused by the amputat'n was nearly healed.
25	Hueter. Langenb. Arch. Vorläufige Mittheilung.	F. 23 years. l.	Healthy.	Exists since 8 yrs. Pulse hardly perceptible. Difference in circumference 16″ and 29″.	Double ligation of iliaca ext. rendered difficult through strong polster of fat. Ligs. separate on the 10th and 14th days.	Peritonitis.	Rapid decrease of about 3 to 9 cm.; after 3 weeks, about 14 to 20 cm.	Almost complete cure after 3 weeks. According to Fischer, the art. fem. gets ligated later, on account of partial relapse. Success of this, as well as of a second operation, unknown.
26	Knorre. Bei Leisrink.	F.			Art. femor.		In the beginning, diminution of swelling.	Relapse.
27	Busch. Arch. für klin. Chir., Bd. 13, S. 60.	M. 36 years. l.	Left foot thicker from birth. Frequent attacks of erysipelas; at last every 14 days. Difference of circumf. moderate. Skin normal.		Lig. art. cruralis.		Decrease of circumference on the 10th day about 7 cm.	Erysipelas on the 14th day. Death on the 18th day.
28	Andersen. Lancet, Dec. 10, 1870.	F. Young.			Lig. iliaca externa.		In the beginning, considerable improvement.	Relapse after 1 year.

No.	Author. Year.	Sex. Age. Side of the Body.	General State of Health before the Operation.	Symptoms. Duration of the Disease.	Treatment.	Accidents after Ligation.	Immediate Success.	Later Results.
29	Jubiot. Marseil. médicale, 1872, Novembre 5. Wiener klin. Wochensch., 1873.				Lig. of art. femor. close by sartorius muscle.		Cure.	Relapse. After 12 years the old circumference re-established.
30	Leisrink. Zeitschrift für Chirurg., Bd. 4, S. 12, 1873.	F. 50 years. r.	Erysipelas 25 years ago, 3 attacks; after every attack, increased swelling; since then, progressive swelling, witho't new considerable lymphorrhœa. Loss of strength; emaciation.	Prodigious swelling of right foot. Papular eruptions; deep, moist furrows. Difference of circumference 23 to 36 cm. Inguinal glands swollen.	Ligat. of fem. artery at middle third. Rich exudation of lymph out of the operation wound, but no longer from the lower leg.		Rapid decrease of circumference. The patient recovers. About the time of discharge, again a slight increase of about 1 cm.	May be considered as the beginning of a relapse.
31	Rotter. Artereinligatur bei Elephantiasis arabum. Deutsche Zeitschrift für Chirurg., Bd. 4, H. 4, 1874.	M. 20 years. r.	Feeble, but never very sick. Eruption, with formation of papulæ on arms and legs. Keeps himself up on the right leg. Swelling of leg down to the foot, and then erysipelas.	Anæmic. Bones and muscles scanty. Glandular swelling in the right groin only. Colossal swelling of right lower leg. Thickening of skin and epidermis. Deep furrows at the ankle. Enormous swelling of foot and toes.	Ligat. of fem. artery at middle third.	Lively, rapidly developing fever. Increase of fever on 14th day. Knots and ulcers, with pen'trating smell; also the healthy lower leg begins to decrease in circumf. Methodical compression with rubber bandage.	Rapid decrease from 2 to 3 cm. Diminution of circumference about 7 cm., and more. General health good. Tibia thickened.	After 9 mos. still the same favorable condition.
32	Kapeller. Chirurg. Beobachtungen aus dem Thurgauischen Cantonspitale, 1874.	F. 52 years. l.	Since the 19th year violent pains both by day and night. After 1½ years' existence the lower leg, from foot up to the tibia, gets covered with white semicircular blisters, which do not burst, but dry up into white spots. Leg swells now, and gets red. Ruptures mostly considerable. Flow of lymph facilitated. New swelling when these ruptures had closed. Fever, with renewed swelling. Abscess for 4 years; swelling of thigh also.	Skin solid, tough. Color on thigh normal; at lower leg rosy. Difference of circumference 10 to 17 cm.	Lig. of art. femor. close under Poupart's ligament. Falls off on the 14th day.	Considerable fever. Decrease of fever from the 4th day.	Circumference decreases visibly. Wrapping up. Strips of 5 cms. length and 2 to 3 cms. breadth are cut out of the swellings, and healed by first intention. Is discharged with a closely applied bandage.	Cure after three-quarters of a year still maintained.

REMARKS ON THE LIGATION OF THE TRUNK

OF THE

COMMON FEMORAL ARTERY,

IN RELATION TO

SECONDARY HEMORRHAGE FOLLOWING AMPUTATION OF THE THIGH,

AND IN

HEMORRHAGE FROM WOUNDS OF THE PLANTAR ARTERIES, AND OF THE POSTERIOR AND ANTERIOR TIBIAL ARTERIES.

The application of the ligature to the common femoral artery has generally been considered an operation attended with unusual danger, on account of the position of the circumflex iliac and epigastric arteries, and the possible flow of reflux circulation from the arteria profunda. Smaller branches of minor importance also spring from the arterial trunk along its course, which might tend also to interfere with the formation of the coagulum and the adhesive process necessary to the agglutination of the arterial tunics after the application of the ligature. From the anatomical data thus afforded, suggesting possible dangers from securing the artery along the course of the common trunk, the external iliac has been selected by preference, or the vessel has been tied below the profunda in the lower part of the space known as Scarpa's triangle. The several instances in which I have had occasion to tie the common femoral artery would induce the belief, however, that these unfavorable anticipations are based only on theoretical suppositions, and that a ligature can be applied with as much safety on the common femoral trunk as upon the artery below the origin of the arteria profunda. In the cases related below, the ligatures came away without any untoward circumstance, leaving the vessel entirely closed, notwithstanding two of the patients were cachectic and broken down in constitution from long-continued disease.

The trunk of the common femoral artery is a continuation of the exter-

nal iliac, obtaining the name from its situation, and is generally about two inches in length, extending from the middle of the crural arch to the point at which the arteria profunda commences. The profunda sometimes takes its origin higher up by an inch or more than the position already indicated, thus shortening the trunk, and bringing nearer together the different points of egress of the minor arterial branches from the tube of the vessel. Other anomalies exist, but as they are not exact in recurrence, the varieties, if met with, must be treated as they occur. The common femoral is found in Scarpa's triangle covered only by the integuments, the superficial fascia, some inguinal ganglia, and the fascia lata. The vessel is enclosed in its sheath with the femoral vein, while the anterior crural nerve is external and not in close apposition. Two or three branches of the nerve lie very near the artery, one small nerve crosses it, and, lower down, the saphenus nerve descends in the sheath along the front part of the descending vessel. The artery rests on the psoas and iliacus muscles, and passes over the pectineus and upper part of the short adductor, from which it is separated by loose cellular membrane and several small vessels. The branches given off by the femoral trunk are: first, three or four superficial branches, chiefly to the inguinal ganglia; the superficial epigastric; the external circumflex ilii; and, lastly, the arteria profunda. The artery as it descends from the middle of the crural arch is very superficial, and, in operating, its pulsation on the living subject is a sufficient guide for the external incision. This incision is made in the direction of the artery downward, starting from the crural arch, to the extent of from one and a half to two inches in length. The skin and cellular tissue divided, a director is passed under the fascia, which is slit up so as to expose the vessels. The vein, which is the larger, is first seen bulging over the artery. This is pressed inward, and the sheath of the vessels opened, and with a few scratches of the director an opening is gently made for the passage of the aneurism needle. This is insinuated between the artery and the vein, the point of the instrument being directed from the vein so as to emerge on the external side of the artery. The ligature is then tied about one inch below the margin of the crural arch, taking care that the place of election for the ligature shall be sufficiently

removed from the origin of the profunda. The main artery having been tied, ligatures are then placed around any of the smaller branches which may be seen springing from the vessel near the main ligature.

Case I. C—— B——, of strumous habit, æt. 15, when at school fell and injured his knee badly, receiving at the same time a severe shock to the system. Soon afterward the clavicle was attacked with strumous ostitis, followed by abscess in the supra clavicular triangle. This continued to discharge for about eighteen months, and was followed by severe ostitis, involving the entire lower third of the femur. Extensive abscesses formed around the femur, ascending above the middle of the thigh, associated with hectic fever and great emaciation. The tissues around the femur were much disorganized by the long continuance of the discharge. Nine months after the appearance of the abscess of the thigh, and the inflammation of the bone showing no signs of resolution, on account of the sinking condition of the patient, amputation at the middle of the thigh was resorted to. The operation was speedily performed by the double-flap method, the bone being sawed through at the middle of the shaft of the femur. The tissues of the flaps were found to be much softened, and the branches of the posterior flap bled freely and were unusually large. Every care was taken to secure the bleeding vessels, but it was remarked during the application of the ligatures that the tissues were unusually fragile, and gave way too easily as the loops of the ligatures were drawn tight. The flaps were brought together in a transverse line, silver sutures being used so as to promote union by first intention. The healing process seemed to be progressing favorably at some points of the stump, but on the sixth day after the amputation blood began to ooze from the lips of the wound, and secondary hemorrhage became fairly established. An assistant who was watching the patient immediately applied the tourniquet, which controlled the bleeding for the time. A messenger was then sent for me, and I reached the patient's house at 6 P.M., about two hours after the bleeding had commenced. I found the patient almost pulseless, pale, cold, and covered with clammy sweat. I sent a message to my old friend and preceptor, Valentine Mott, who met me at nine in the evening. We concluded to leave the patient for the night without interference, as the

tourniquet controlled the hemorrhage for the time, and in the hope that by the use of beef tea and cordials sufficient reaction would set in to enable us to take the necessary steps to arrest the bleeding permanently. Twelve o'clock next day was appointed for consultation. The bleeding still recurred continually upon unscrewing the tourniquet. The condition of the patient was improved. It was not thought expedient to open the flaps and make the effort to secure the bleeding branches from which the blood flowed freely. The ligature upon the common trunk of the femoral artery was therefore selected as the safest practice in the emergency. The ligature was applied about an inch below Poupart's ligament. Several small branches springing from the trunk near the place of election for the ligature were also tied, in order to secure the formation of the coagulum. The ligature came away on the fifteenth day without any accident or untoward circumstance, and the stump was entirely healed within three weeks of the operation.

Case II. E—— T——, baker by occupation, æt. 35, robust constitution, fell on the ice while skating, and, besides wrenching the limb, received a severe contusion of the soft parts, and of the bone at the lower third of the femur. Inflammation of the soft tissues and ostitis soon set in, followed by abscess. The bone became extensively diseased, keeping up a profuse discharge of pus along numerous sinuses opening upon the surface. The constitution became so undermined that I deemed amputation of the thigh necessary. The double-flap operation was selected, and an unusual number of enlarged arterial branches required the application of the ligature. On the nineteenth day after the operation secondary hemorrhage occurred. Compression and cold applications to the stump, with the use of the tourniquet, were tried for forty-eight hours, without avail, to stop the hemorrhage. The common trunk of the femoral was therefore tied an inch below Poupart's ligament, taking care to ligate any small branches springing from the trunk in the vicinity of the main ligature. The ligature came away from the femoral on the thirty-fifth day without accident, and the patient had a rapid convalescence.

I may mention in this connection that when secondary hemorrhage takes place after amputation at the middle portion of the thigh within a few

days of the operation, the bleeding is very likely to proceed from branches of the profunda which ramify through the posterior flap. Some branches pass along the posterior aspect of the bone in close proximity to it, enveloped in dense tissue. These are difficult to tie, even when picked up by the tenaculum, and should receive particular attention. If the ligatures are not placed properly at first, the vessels should again be taken up with the tenaculum, and carefully secured. It should not be overlooked that the tissues, in many cases requiring amputation, are softened by protracted disease or extensive abscesses, and easily give way under the pressure of the loop of the ligature.

Case III.—Wound of the Plantar Arteries. M—— C——, a young man about 30, of good constitution, whilst occupied in his business as bar-tender, in passing hurriedly over a cellar floor, wearing thin shoes, stepped upon a piece of broken bottle, from which he received a severe and deep transverse wound of the sole of the left foot, which severed the internal and external plantar arteries. He was attended by a practitioner who was not conversant with the full importance and gravity of the injury, and who used direct compression, by means of compresses and tight bandaging, to restrain the hemorrhage. This stopped for a time the flow of blood, but the tightness of the bandage became insupportable, and after some hours the dressings had to be removed. This was immediately followed by a free return of the bleeding, which for the moment was again controlled by the application of a tourniquet over the femoral artery at the groin, and by a re-application of the dressing of the wound by compress and bandage, although this time not so tightly drawn. This treatment was maintained for about twenty-four hours, when it became necessary to relax the tourniquet. The bleeding again recurred, and was again stopped by a repetition of the former treatment. Upon unscrewing the tourniquet next day the bleeding again commenced. The tourniquet was immediately made tight, and, the case now assuming an alarming aspect, he was removed from his house to the clinique of the New York Medical College. Upon my visit to the college about an hour after his admission, the patient was brought into the operating amphitheatre and placed on the table for examination. I found him pale and feeble, suffering

from the effects of loss of blood. Upon removing the dressings and relaxing the tourniquet, the blood gushed furiously from the wound. This was promptly stopped by screwing the tourniquet. The parts were then sponged and cleaned of the coagulum. The foot had now become generally swollen, and the soft tissues on the plantar aspect were found much infiltrated with blood and serum. The bottom and sides of the wound were found to be infiltrated with extravasated blood, softened, and inflamed, free hemorrhage following each loosening of the tourniquet. It was now evident that some treatment was called for different from that which had been pursued. The tissues in and around the wound had become too soft and disorganized to admit of the application of ligatures to the distal and proximal bleeding orifices of the cut vessels, and nothing remained to be done but to tie the femoral artery either above or below the origin of the arteria profunda. Anticipating continued hemorrhage from the supply of blood through the branches of the profunda, I preferred to apply the ligature upon the trunk of the common femoral artery, which was done by securing the vessel about one inch below Poupart's ligament. The bleeding immediately ceased, and there was no farther recurrence of it. The ligature came away on the eighteenth day without accident. The wound in the foot healed rapidly under simple dressing.

Case of Wound of the Posterior Tibial Artery.—In contradistinction to the last case recorded, another came under my observation some years since, which I saw only toward its termination. A carpenter by trade, while running with an old-fashioned fire-engine, was thrown down under the engine, which passed over his right leg, about the middle. The leg was excessively bruised, ecchymosed, and lacerated, and the posterior tibial artery and veins were torn, causing a profuse hemorrhage. The tourniquet applied tightly over the femoral artery controlled the bleeding, and owing to the extravasation and infiltration of the tissues at the seat of the injury in the leg, a ligature was placed around the femoral artery a short distance below the profunda. This failed to arrest the hemorrhage permanently, and then an effort was made to secure the posterior tibial artery above and below the opening in the wounded artery. After great difficulty and much groping

among the infiltrated tissues, this was accomplished, and the bleeding arrested, but the patient died within twenty-four hours after the last operation. In this case, had a ligature been placed around the common trunk of the femoral artery above the profunda in the first instance, I believe the result would have been a favorable one.

I quote in this connection some remarks of the late Mr. Lawrence, of St. Bartholomew's Hospital, London, in a clinical lecture on wounds of the blood-vessels of the lower extremities, from the London *Times and Gazette*, June 11th, 1853:

"When arteries under the calf of the leg are wounded, it is difficult to follow the well-founded and generally received rule of exposing and securing the injured vessels, even under the most favorable circumstances; that is, if we see the case at an early period, when no considerable swelling has occurred, and the natural relations of the surrounding parts are not obscured by ecchymosis.

"Frequently we do not know what vessel is wounded, nor the precise locality of the mischief. Sooner or later, and often very quickly, the whole limb becomes swollen by extravasation of blood, while all the soft structures may be lacerated, contused, and infiltrated with blood. Exploratory incisions for discovering the injured vessel would be undertaken with very little chance of success. In such a state of limb, they might be attended with dangerous loss of blood, and would certainly involve the necessity of extensive and deep incisions in the injured parts. Thus we come to the conclusion that amputation is necessary in some of these cases, in order to prevent worse consequences."

Mr. Lawrence proceeds to mention a case of violent contusion of the leg, with rupture of the anterior tibial artery, in which he had recourse to amputation of the thigh in order to save the life of the patient. In this case the posterior tibial vein was wounded, causing, it was supposed, great effusion of blood. It seems very probable that if on this occasion the trunk of the femoral artery had been tied, so grave an alternative as the amputation of the thigh would have been avoided.





AMPUTATION OF THE ENTIRE LOWER JAW.

Fig. I.

Appearance of the patient four months after the operation. Upon the side of the face the cicatrix is seen, shewing the line of the external incision. A similar incision, made upon the opposite side, meets the other at the chin.

Fig. II.

The lower jaw after maceration, generally diseased.

a. Condyles of the jaw.

b. Rami of the jaw.

c. Body of the jaw in a State of necrosis and seen as separated during the operation.

AMPUTATION

OF THE

ENTIRE LOWER JAW.

The chief utility of recording severe surgical operations may be said to consist in proving that life may be preserved and sustained after they are performed with judgment and care. In the two operations which follow, where the entire lower jaw was removed in each instance, the patients had a perfect recovery, and lived in comparative comfort after cicatrization was completed. In one case the operation was performed for necrosis and caries of the jaw; in the other, the lower jaw was removed by operations at two different times—*à deux temps*—for osteo-fibroid tumors of considerable size. Previous to the date of the first operation, so far as I know, the entire lower jaw had never been removed successfully at one sitting.

[*From the New York Journal of Medicine*, 1852.]

Notwithstanding the repeated instances on record of large portions of the lower jaw having been lost by accident or disease, surgeons appear to have been slow in admitting the possibility of practising amputation, either partial or total, of this bone. To Dupuytren was reserved the glory of having, in 1812, first removed, by a methodical operation, a portion of the body of the inferior maxilla; but since the innovation of the celebrated French surgeon, the operation for the partial exsection of this bone has been repeatedly performed. In the annals of surgery there is an *allusion* made to the amputation of the *entire* lower jaw, by Walther, of Bonn; but I have not been able to trace the truth of it to an official source.

The following case will prove that this operation can be performed with success, and that the patient, although deprived of the chief instrument of mastication, may survive, and enjoy the usual condition of health.

Nicholas Donegan, aged 43, a farmer by occupation, was admitted into the New York Emigrants' Hospital, March 7th, 1851. He was treated for some weeks, in the Medical Division, for typhus fever, and was afterward transferred to the Surgical Department, under my charge. Upon examination of the patient, his face presented much tumefaction, and he complained of great pain, seated chiefly in the region occupied by the inferior maxilla. Upon carrying the examination further, the lower jaw was found to be extensively affected with ostitis and necrosis. All the external appearances denoting a cachectic condition of the constitution, with extreme debility and general prostration of the vital functions, were present. The patient stated that, during his recent voyage to this country, he had received a severe blow upon the lower jaw and side of the face. This circumstance, coupled with the cachectic condition following the attack of fever, appears, as far as can be learned, to have been the origin of the disease of the bone.

A tonic course of treatment was prescribed for him, and various local applications and lotions were resorted to, in order to allay the irritation in the mouth and abate the fetor emanating from the disease. In a short time the teeth became loose, and had to be extracted; the alveolar ridge became partially denuded; the swelling increased toward and over the rami and condyles; and the patient complained of excruciating suffering and depression. Nutritious diet and the various therapeutic agents proper to improve and renovate his system were persevered in, and soothing and astringent lotions and applications were unremittingly used. This plan of treatment was pursued for about three months, at the expiration of which time it became evident that the disease of the osseous tissue was too deeply rooted to be affected by mere remedial agents. In fact, they were found to be entirely unavailing. The disease had now apparently seized upon the entire jaw; pus was abundantly secreted into the cavity of the mouth; the saliva was also thrown out in great quantity; and the fetor became almost intolerable to the patient himself and to those around him in the ward. Consti-

tutional irritation and hectic of a grave character had also set in; diarrhœa made its appearance; and the patient was gradually sinking under the complications of his disease and the terrific pain by which he was unceasingly tortured. It was apparent to me that the speedy death of the patient could only be avoided by removing the source of such intense suffering and constitutional derangement. The integuments over the diseased bone, although much tumefied, œdematous, tense, and red, remained free from ulceration, the vitiated secretions taking their exit by the cavity of the mouth.

On the 13th of July a consultation was held, and an operation for the removal of the bone decided upon. The formidable nature of the operation proposed, together with the debilitated and cachectic condition of the patient, induced me to enter into full explanations, and to inform him of the great risk that would attend it. The matter was then left to himself, and, at his urgent request, I proceeded to use my efforts for his relief. It was not thought expedient to administer either chloroform or ether, on account of the liability to asphyxia from the passage of the blood into the windpipe.

The patient being seated on a chair, and the assistants properly arranged, an incision was first made, commencing opposite the left condyle, passing downward toward the angle of the jaw, ranging at about two lines in front of the posterior border of the ramus, extending thence along the base of the jaw, and terminating by a slight curve on the mesial line, half an inch below the free margin of the lower lip. The bone was now partially laid bare, by dissecting upward the tissues of the cheek, and by reflecting downward, for a short distance, the lower edge of the incision. The tissues forming the floor of the mouth, and situated upon the inner surface of the body of the bone, were separated from their attachments, from a point near the mesial line, as far back as the angle of the jaw. The attachments of the buccinator were next divided. The facial artery, the submental and the sublingual, already cut, were then secured by ligature. It was now seen that the bone was partially separated at the symphysis, and that the necrosis was complete from that point to the anterior portion of the ramus. The ramus itself was found diseased; the periosteum externally was inflamed,

and in some parts easily detached. The tongue was now grasped and held forward, while the attachments of the genio-hyo-glossi muscles were divided. A double ligature was passed through the anterior part of the root of the tongue, and intrusted to an assistant, in order to prevent its retraction upon the superior orifice of the larynx. A fatal case, from the falling backward of the tongue, occurred a few years ago in the practice of an eminent surgeon of this city, and a similar misfortune should always be guarded against when the muscular attachments of the tongue to the posterior part of the bone behind the symphysis are divided. A slight force exercised upon the left half of the body of the jaw broke the connection at the symphysis and at the angle, and this part was easily removed. The next step consisted in the removal of the left ramus. The external surface of the branch of the jaw and of the temporo-maxillary articulation was exposed, by dissecting the masseter upward as far as the zygomatic arch. Seizing the ramus in order to pull the coronoid process downward below the zygoma, it was found that the temporal muscle was rigidly and permanently retracted. This circumstance presented an unexpected difficulty, which was increased by the unusual development of this apophysis, and by the retraction also of the pterygoid muscles. Passing the forefinger along the inner aspect of the ramus, the situation of the internal and external carotids was sought for and recognized. The insertion of the pterygoideus internus was then felt and cut, grazing the bone in doing so, the lingual nerve, here in close proximity, being carefully avoided. Passing still higher up, the orifice of the dental canal, indicated by an osseous projection, could be felt; and the instrument, still guided by the finger, divided the dental artery and nerve. The knife was thus made to separate the tissues attached to the inner face of the bone as high up as a point situated about a line below the sigmoid notch, between the condyle and the coronoid process. On a level with this point, at the posterior margin of the ramus, the transverse facial, internal maxillary, and temporal arteries form a kind of tripod, the two last-named branches of which should not be divided, if possible. It now became necessary to detach the tendon of the temporal muscle. As the coronoid process could not be depressed, I proceeded cautiously, by dividing the lower attachments of the tendon by

means of blunt curved scissors; and by using them and a probe-pointed bistoury alternately—keeping close to the bone—a considerable portion of the tendon was divided. Deeming it not prudent to use freely a sharp cutting instrument deep in the temporal fossa, where the coronoid process was situated, I made use of a pair of bone-scissors, curved flatwise; and by passing the blades of this instrument over the process, as far as its position would permit, the temporal muscle was detached, a small portion of the apex of the coronoid process being cut through. The ramus, now movable, could be made use of as a lever to aid in the disarticulation of the bone.

In order to effect safely the disarticulation of the condyle, I began by penetrating into the joint, cutting the ligaments from *before backward*, and from *without inward*. The articulation was thus opened sufficiently to allow the condyle to be completely luxated. Blunt-pointed scissors were now used to cut carefully the internal part of the capsule and the maxillary insertion of the external pterygoid muscle, and, by a slow movement of rotation of the ramus upon its axis, the condyle was detached, and the operation was completed on this side. By proceeding to disarticulate, in the manner here described, injury to the temporal artery, as well as to the internal maxillary, was avoided.

To effect the removal of the other half of the lower jaw, a similar incision was made on the opposite side, so as to meet the first on the mesial line. The dissection was also similar; and by disarticulating the second condyle in the same manner as had been observed for the first, I was successful again in avoiding lesion of the temporal and internal maxillary arteries.

The annexed plate, No. III., Fig. II., is a correct delineation of the inferior maxilla, after maceration, and exhibits the portions of the bone as they became separated during the operation.

The object I had in view, in shaping the external incisions in such a way that an inverted V should be formed in front of the insertion of the genio-hyo-glossi muscles, was to leave a portion of integument so fashioned that the suture pins could be passed through the integument, and, at the same time, through the root of the tongue, at the point where its muscles

had been detached from the inner surface of the jaw. The several tissues becoming thus incorporated in the resulting cicatrix, served to form a new bridle, somewhat analogous to the natural muscular attachments of the tongue to the genial processes.

The amount of blood lost was inconsiderable; the arteries divided, besides those mentioned, were the transverse facial, the anterior masseteric, the anterior parotidean, etc., and these were secured as soon as divided. The bone being disarticulated, the flaps were adjusted, and the lips of the incision united by eighteen points of twisted suture. The tongue was retained forward, after the dressing, by attaching the ends of the ligature already passed through its base, on each side, to a bandage passed vertically around the head. Forty-eight hours after the operation the first dressing was removed: union by first intention had taken place, and eight of the suture pins were taken out. In ninety-six hours the wound was again examined: union was found to be entirely completed, and the remaining pins were removed. On the seventh day it was thought safe to remove the ligature from the tongue. On the tenth day the arterial ligatures came away; and on the fourteenth day the patient was pronounced cured, not having had an untoward symptom since the performance of the operation.

The operation occupied fifty-five minutes, the patient having been allowed intervals of repose to recruit. It was performed in the presence of a number of professional gentlemen; and I was ably assisted by my colleague, Dr. A. V. Williams, Drs. Dewees and Dixon, of New York, and by Drs. Thompson, Whitehead, Smith, and Bailey, resident assistants attached to the surgical staff of the hospital.

The present appearance of the patient, upon reference to the accompanying plate, No. III., will be seen to present much less deformity than might be expected from the severe mutilation which he has undergone. His general condition and health are good, and he is now able to perform any ordinary vocation. The ducts of Steno on both sides were necessarily divided in the superficial incisions; but there is no salivary fistula, the saliva taking its course into the mouth. The division of the branches of the facial nerve has not been followed by permanent paralysis of the face, although, for a

time after the reunion of the incision, the orbicularis palpebrarum of the right side appeared to have lost its action to some extent. In grasping the chin, a thin cartilaginous deposit can now be felt, extending, crescent-shaped, for about three inches, and occupying the position at which the bone was most diseased. Higher up, toward the glenoid cavity, no deposition of bone or cartilage has taken place. Injury to the bag of the pharynx, during the detachment of the soft tissues from the angle of the jaw, was carefully avoided, and fluids could be swallowed, in small quantities, immediately after the operation. Deglutition is now effected without difficulty. Articulation is sufficiently distinct to render his words intelligible, and although unable to masticate, he does not complain of difficulty in eating, breaking up, as he says he does, his food between the tongue and the palatal vault of the superior maxillæ.

Disarticulation of the lower jaw, by external incision, at the temporo-maxillary articulation, can be accomplished without wounding the duct of Steno, or the trunk of the portio dura, as the following case will illustrate: A gentleman about 45 years of age, from the State of Vermont, consulted me for a cancerous growth springing from the body of the lower jaw, upon the right side. The enlargement encroached upon the cavity of the mouth, and also formed a considerable tumor externally. The disease of the bone was supposed, before the operation, to extend from the angle of the jaw as far as the second small incisor tooth of the right side. The operation for removal was commenced by an incision of the soft parts, beginning at a point below the duct of Steno, near the posterior margin of the ramus of the jaw. This was prolonged downward as far as the angle of the jaw, and then carried forward, along the lower border of the ramus, as far as a point opposite the first incisor tooth, with a slight curve, the border of the lower lip not being divided. Upon laying bare the diseased bone, I was induced to believe that the disease extended farther upward upon the ramus than had been anticipated. The remaining portion of the ramus was exposed by dissecting, and by pushing upward with the handle of the scalpel the tissues resting upon

it. The jaw was now divided by the chain-saw opposite the second incisor tooth. This allowed the diseased portion to be depressed so as to place within reach the insertion of the temporal muscle. A pair of bone-scissors, blunt on the point, and curved flatwise, was made to separate the temporal muscle at its insertion into the coronoid process. The tissues over the articulation were then drawn upward, and the joint being entered at its external and anterior part, disarticulation was easily accomplished.

NOTE.—I have in the text, as originally written, given the credit of priority to Dupuytren for the removal of a part of the lower jaw. Professor Eve, in his recent work, *Collection of Remarkable Cases in Surgery*, has brought forward very strong evidence in favor of Dr. Deaderick, of Tennessee, as the originator of this operation. The question stands thus: Dupuytren's case was recorded in 1813, and published to the scientific world; Dr. Deaderick's case is said to have occurred in 1810, but was not published until 1823; in other words, it was a claim made after thirteen years of silence on the subject. The name of my celebrated and esteemed preceptor, Professor Mott, is also identified with the early operations for partial removal of the lower jaw. In fact, Professor Mott's first operation for the removal of a portion of the lower jaw, for osteo-sarcoma, was published in 1822, or one year prior to the publication of Dr. Deaderick's case.

REMARKS

ON

AMPUTATION OF THE ENTIRE LOWER JAW.

[*From the New York Medical Journal, May*, 1852.]

Since the publication of my case of amputation of the entire lower jaw in the January number of the *Journal*, I have been led to investigations which justify me in presenting it as the first successful operation of the kind reported in the annals of surgery. The operation attributed to Walther, of Bonn, cannot be admitted as authentic; not because it presented formidable surgical difficulties, although such must always exist, but because no such operation is recorded either by himself or by an eye-witness. I am not alone in this opinion. Velpeau, the great compiler of surgical literature, alludes to it in a brief note [*Nouveaux Élémens de Médecine Opératoire.* Paris, 1839. Vol. ii., p. 610] as a mere rumor, unsustained by proof. Nélaton [*Élémens de Pathologie Chirurgicale.* Paris, 1849. P. 749] also alludes to the operation as a mere rumor. The most eminent German authority, Dieffenbach, in his Operative Surgery [*Die Operative Chirurgie.* Leipzig, 1848. Zweiter Band. P. 56], under the caption of "Exarticulation of the Entire Lower Jaw," describes a *cadaveric* operative procedure, but makes no allusion to Walther in this relation. Chelius, another eminent German professor [*System of Surgery.* By J. M. Chelius. Translated from the German, with notes, by John F. South. Vol. iii. Philadelphia, 1847. P. 745], under the caption of "Excision of the Lower Jaw," says that "even the *total extirpation of the lower jaw* may be indicated by various kinds of disease," but does not proceed to mention Walther, or any other surgeon, as ever having performed

that operation. From this silence it may be inferred that he assumes that the operation was thitherto wholly unknown in the records of surgery. The latest French authority, M. Vidal (de Cassis) [*Traité de Pathologie Externe de Médecine Opératoire.* Paris, 1851. Vol. iii., p. 509], holds this language in regard to Walther's operation: "Success (in an amputation of the entire lower jaw) is attributed to Walther, of Bonn;" and further on, "the success spoken of is unique; it has not even an irreproachable authenticity."*

There is an operation transcribed from the Italian into the *Gazette Médicale* for November, 1854, p. 758, under the head of "Extirpation of the Entire Lower Jaw by subcutaneous incision, by M. Signoroni," but it is very far from coming within the category of successful amputations or resections. The record is in many respects vague and unsatisfactory: No details are given of the disease requiring the operation. The operation itself, according to the author, was not an amputation properly so called, but an extraction of the bones, by means of forceps, and the use of the bone-scissors. There were no incisions made, except of the buccal mucous membrane, where it is attached to the surfaces of the jaw. Moreover, the extraction was not effected by a single operation, but required a second, after the lapse of eight days. And still farther, the patient was not cured; for, according to M. Signoroni, "at the end of nine months he succumbed to a reproduction of the disease."

Professor Syme [*Contributions to the Pathology and Practice of Surgery.* Edinburgh, 1848. P. 21], in the article on "Excision of the Lower Jaw," states that he disarticulated the jaw; but no details are given of the case or of the operation. Moreover, the patient referred to is stated by him to have died on the following day.

Mr. Perry's case, related in the *Medico-chirurgical Transactions* [London, second series, vol. iii., 1838, p. 290], like that of M. Signoroni, was an extrac-

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* Beaucoup d'auteurs français attribuent la première extirpation du maxillaire inférieur à Walther et à Graefe: mais c'est une affirmation sans fondement. [*Traité des Resections* par le Docteur O. Heyfelder, traduit de l'Allemand par le Docteur Eugène Bœkel. Strasbourg—Paris, 1863.] In the *New York Medical Journal*, vol. x., new series, 1853, the editor states he is promised the details of a case of amputation of the lower jaw, but I have not been able to find a record of it.

tion of the bone, piecemeal, at intervals, extending over a period of three weeks.

It would be easy to multiply negative facts of this kind; that is to say, to adduce cases where the operation of amputation of the entire lower jaw was not performed; but those I have noticed and commented upon will suffice for my purpose. In reality, my claim to priority, which I now feel entitled to make, is based upon the positive fact that there exists no record, antecedent to my own, of an operative procedure of amputation of the entire lower jaw, performed with success upon the living body.

In regard to that operation, it was performed upon a principle analogous to that which would govern the amputation, in contiguity, of any other member similarly affected by disease. For example, the removal of the upper extremity at the scapulo-humeral articulation would be preferred to an operation with section of the bone, where the disease was likely to return if any portion of the shaft or head of the humerus were allowed to remain. As mentioned in the published report of my case, the body, only, of the bone was in a state of necrosis. To be more definite, the necrosis extended to the anterior edge of the masseter muscle of the left side, and some lines farther upon the right side. But, although the necrosis did not extend beyond the body of the bone, the condition of the rami, on both sides, was such as to demand their removal. They were already inflamed, and if they had not been removed, they would have remained liable to caries or necrosis in the progression of the disease; the maxillary muscles having become rigidly and permanently retracted, from the irritation of the disease, would have drawn, by the action of the pterygoid muscles, the ramus of each side upon the bag of the pharynx, and so impeded deglutition; while the immovable position of the rami, occasioned by the permanent contraction of the temporal muscles, attached to the coronoid processes, would, upon the deposition of new bone, have led to increased irritation and danger. Lastly, the dilapidated condition of the patient, and the danger of purulent infection to which he was exposed from the quantity of pus secreted by the diseased parts, together with his inability to endure much longer the torture under which he was laboring, from the irritation propagated to the ramifications of the third

branch of the fifth pair of nerves, lodged in the dental canals, furnished an additional reason for total disarticulation.

In conclusion, I may remark that the patient now, ten months after the operation, is pursuing his vocation as a dairy-man, in a state of perfect health. The morbid specimen is deposited in the museum of the New York Medical College.

The foregoing "Remarks on Amputation of the Entire Lower Jaw," taken from the *New York Medical Journal* for May, 1852, were written in answer to some observations made in one of the medical journals of the day in relation to my case operated on in July, 1851. I see no reason, at the present time, to modify the statement I then made, and leave the article as formerly published. Before, and particularly since 1851, military surgery has afforded numerous cases of injuries of the inferior maxilla, in many of which the bone was so shattered as to require at the time or at a future period the extraction of nearly the whole of the jaw, piecemeal. [Vide Larrey, *Mémoires de Chirurgie Militaire.* Paris, 1812. Also *Medical and Surgical History of the War*, First Surgical Volume, p. 345, 1870.] The first formulized operation on record, however, where the whole jaw was removed with success at one sitting, for disease that required a methodical dissection, appears to have been performed on the patient upon whom I operated. Even at the present time there are but few instances where the inferior maxilla has been removed successfully by formal operation. In addition to the references of cases previously made, I may mention those of J. F. Heyfelder, the first of which occurred in 1843, the operation having been performed on a young girl, *à deux temps*, with an interval of fifteen months between the first and second operations. Two operations of a similar character are recorded by the same surgeon, one in 1852, and one in 1858. All of these operations appear to have been required for phosphoric periostitis and necrosis. [Vide *Traité des Resections*, par le Docteur O. Heyfelder. Traduit. Paris, 1863.] Maisonneuve reports two cases, one of operation for cancer of the bone, wherein the operation was performed *à deux temps*, the first

operation having been done on the left portion of the jaw, July 17th, 1851. Fifteen months after this operation, the disease having returned on the other side, the remaining half of the jaw was removed. [*Bull. Acad. de Sciences*, 3 Mai, 1853.] The same surgeon records another case, in which he removed the entire lower jaw, at one sitting, for a fibrous tumor as large as the fist. This case is recorded at length in the *Bulletin of the Academy of Sciences*, 12th May, 1856; 10th August, 1857. The patient, æt. 33, entered the Hôpital de la Pitié April 11th, 1856, and was operated on a few days after. This is probably the first authentic record of any case of the kind performed in Europe. The periosteum in Maisonneuve's case was preserved to a great extent, which should be avoided where a cancerous predisposition is apparent. As will be seen by reference to the dates, I have to place my case as the first on record, having been performed July, 1851.*

The following case is one where the entire lower jaw was successfully amputated for osteo-fibroid tumor.

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* Cases are often quoted and copied from book to book by successive authors, and mistakes are transmitted unintentionally, from neglect to consult the original publications. Thus we have Butts, of Virginia, credited in almost all the works on operative surgery issued during the last twenty-five years with the first removal of the entire radius, when, in the case as originally published, it is found that his operation was upon the ulna, and not upon the radius at all, and that two-thirds only of the lower or carpal portion of the ulna were resected, the elbow joint not being implicated in the operation. The case is fully detailed, and a plate given representing the portion of bone removed. [Vide *Philadelphia Journal of Medical and Physical Sciences*, vol. i., new series, p. 115, Art. ix.] V. Mott is credited with having removed the entire clavicle, when the description of the operation as published states that the bone was sawed through with a chain-saw near the coracoid process, thus preserving some attachments, to the portion of the clavicle remaining, of the trapezius and deltoid muscles, making an important difference in regard to the functions of the humero-scapular joint. [Vide *American Journal of Medical Sciences*. Philadelphia, 1828. Vol. iii., p. 100. Also Mott's *Velpeau*, edited by Blackman.] Other instances of a similar character might be alluded to. I have failed to find any case, reported by the author, of an operation where the whole jaw was removed by a regular operative procedure at one time prior to my case, and have left unnoticed cases mentioned by miscellaneous authorities, concluding that an operation of such importance as the removal of the entire lower jaw was not likely to have escaped so far the attention of the operator as to induce him to forego recording the operation himself in accustomed form and detail.

AMPUTATION

OF THE

ENTIRE LOWER JAW FOR OSTEO-FIBROID TUMOR,

À DEUX TEMPS.

In May, 1864, I was consulted by M—— J——, a lady about 40 years of age, married, of nervous temperament. She had been operated on, three years before, for an osteo-fibroid tumor on the left side of the lower jaw, the growth commencing at the site of the second large molar tooth, and extending gradually, during a period of eighteen months, up the ramus of the same side, and passing forward as far as the second small molar. This operation was performed in 1861, the bone having been sawed through opposite the first small molar, and disarticulated at the left condyle. The patient had a good recovery, the wound healing in about four weeks. In six months after this operation the end of the stump of the portion of the jaw that remained began to take on a diseased action, similar in character to that of the tumor already removed. This continued to enlarge and to extend upward, at first occupying the centre of the body of the bone, and then the rest of the body as far as the angle of the jaw. At the time that she visited me for advice, May, 1864, she presented an appearance of great suffering and of broken-down health. On the left side of the face the cicatrix of the former operation was visible, and opposite the spheno-maxillary fossa a hard lump, as large as a walnut, was seen, which had sprung up some months after the first operation. The entire middle of the body of the bone and the horizontal portion were diseased, and presented a spherical tumor



AMPUTATION OF THE ENTIRE LOWER JAW, À DEUX TEMPS.

Fig. I.

The patient before the operation, representing the tumor of the jaw with the line of incision indicated.

Fig. II

Represents the three-fourths of the jaw last removed, the other portion, on the left side, having been resected some time previous A portion of the coronoid process was cut off by the bone forceps and dissected out to facilitate the operation.

as large as the two fists, extending from above downward, toward the malar bone, and below as far as the os hyoides, and transversely from the alveolar ridge of the left canine tooth along the mental and horizontal portion of the body of the bone, a little beyond the place of junction of the body with the ascending ramus of the right side. The morbid mass thus springing from and making part of the inferior maxilla encroached upon the floor of the mouth, pushing the tongue upward and to one side, pressing upon the salivary glands, ducts, and nerves toward the pharynx. The carotid artery could be felt on the side of the neck upon a level with the cornu of the os hyoides. The buccal cavity presented several teeth irregularly projecting from the surface of the tumor, and from the left extremity of the mass unhealthy granulations were springing up and pouring out a viscid and offensive secretion. The temporo-maxillary articulation was perfectly free, but the angle of junction made by the body and ramus of the jaw, on account of the growth of the tumor, had become much more obtuse, giving the tumor an inclination downward and forward. The skin covering the morbid growth was rough, and showed large blue varicose veins ramifying over the surface, while the tumor itself gave to the touch a hard, unyielding, and somewhat nodulated sensation.

The collected important scientific facts connected with operations for partial amputations of the inferior maxilla, and the successes which have followed them, have been sufficiently numerous to render almost unnecessary any additional detailed accounts of such achievements. In cases, however, where removal of the *entire* lower jaw has been undertaken, the data are not so abundant, and farther observations may prove useful and interesting.

The position in which the patient should be placed during the operation, the extent to which anæsthetics can be prudently administered, the propriety or necessity of ligating the carotid artery as a preliminary step to the operation, the precautions required to prevent the falling back of the tongue upon the upper part of the larynx, and the safest manner of effecting disarticulation of the condyles, are points which admit of deliberation and study. In severe operations on the jaw, the sitting or semi-recumbent position is best, and the anæsthetic influence should never be carried to the point of insensibility. By adopting this precaution the patient will run less

risk of being killed by apnœa, or of succumbing in case of fainting from loss of blood. The more precise knowledge of the surgical anatomy of the blood-vessels concerned in these operations has rendered the ligation of the common carotid artery, as a preliminary step, an exceptional measure, as well as taught that the best mode of proceeding in the disarticulation of the maxillary condyle from the glenoid cavity is to attack the articulation in front, and to continue the section of the capsule from before backward.

Where large portions of the lower jaw have to be amputated, operators who have had most experience in this class of cases have taken pains to lay down rules in relation to the shape and direction of the line of external incision, having in view the prevention of deformity from the resulting cicatrix, and the promotion of the egress of saliva and pus from the cavity of the mouth. These incisions have been in general semi-lunar in form, with the convexity directed downward, or downward and backward. This shape is preferable among the various plans which have been adopted for laying bare the disease and lessening disfiguration; and, to the general semi-lunar form, when three-quarters or the whole of the jaw has to be removed, I have practised the prolongation of the incision so as to ascend in a curved direction to a point on the mesial line within half an inch of the free border of the lower lip. From this point the incision for the opposite side is commenced, and carried in the direction corresponding with the incision on the other side, and terminating at a given point, or at the temporo-maxillary articulation, according to the extent of the diseased portion. From the direction of the line of incision in front, we have thus a *point d'appui*, or *pièce de résistance*, for incorporating the detached base of the tongue with the more solid tissues of the external flap, and by not carrying the incision through the free border of the lip, the labial arteries are not divided, and hemorrhage from these vessels is, therefore, avoided during the first steps of the operation. I may here mention that, although the general line of incision should be determined upon before commencing an operation, where the external incision has to be so extensive it is prudent to make it by degrees, and not all at once. The blood-vessels of the neck are near the centre of circulation, and bleed actively, and by subdividing the general in-

cision into several, and securing the vessels as they are cut, the loss of blood may be considerably abated.

In the following operation the patient was seated on a chair facing the light, and chloroform administered so as to produce only partial anæsthesia. An incision was commenced on the mesial line, half an inch below the surface of the free border of the lip, and carried backward and downward over the tumor to a point opposite the middle of the right side of the body of the jaw, in a semicircular sweep, slightly below the lower border of the face. From this point the incision was prolonged, still coursing from before backward, and a little below the lower margin of the body of the bone, as far as within a few lines of the angle of the jaw, thence extending upward within a line of the posterior border of the ramus as far as a point immediately above the superior and middle part of the condyle, in front of the temporal artery. This incision divided the integuments, the platysma myoides, and subcutaneous layer of cellular tissue. The dissection now was confined to that part of the tumor between the commencing point of the incision at the chin and the place of transit of the facial artery over the side of the jaw, and the surface of the tumor reached for three-quarters of its extent. The dissection was also carried deeper along the side of the neck, as far as the angle of the jaw, dividing the facial artery and vein, the former of which was immediately secured, and laying bare the bone. The bone at and above the angle was found to be thickened and diseased, and, with the presence, besides, of an apparently cancerous diathesis, there was no longer any doubt as to the necessity of disarticulating the condyle, so as to get rid of the entire bone. The dissection was now carried deeper, in order to reach the bone along the posterior border of the ramus as high as the condyle, thus dividing the superficial tissues, branches of the portio dura, small masseteric branches, and a portion of the parotid gland. The tumor and ramus being thus laid bare on the external aspect, and the bleeding vessels secured, the dissection was continued, so as to detach still farther the sound tissues from the tumor in this direction. This accomplished, an external incision, similar to the first, was begun on the other side of the tumor at the same point, and carried outward so as to sweep over the left external aspect

of the diseased mass and beyond its posterior margin. The tumor in this direction was promptly laid bare without much bleeding, and the healthy and soft tissues separated from the diseased by carrying the knife downward, backward, and forward, so as to open the cavity of the mouth. The left lateral and anterior aspects of the tumor being now exposed, the upper flap was farther detached, from below upward, so as to divide the cheek completely as far as the anterior border of the ramus. The lower flap was now dissected downward toward the os hyoides, and upon the neck as far as the angle of the jaw. By this the anterior and inferior parts of the tumor were exposed, as well as the whole length of the inferior margin of the body of the jaw. It remained now to detach the tumor from its attachments to the os hyoides, the root of the tongue, and the floor of the mouth, and to effect the disarticulation of the condyle after freeing the attachments of the masseter, temporal, and pterygoid muscles. Before dividing the genio-hyo-glossi muscles attached to the middle of the posterior part of the tumor, a double ligature was passed through the substance of the tongue, and the ends confided to an assistant, a double hook was also inserted in the tongue, and directions given to carry this organ upward and to one side, so that it would not interfere with the incisions. The lip and upper flap pulled up, and supported by another aid, the knife was carried closely along the posterior aspect of the tumor from left to right, and the genio-hyo-glossi, the genio-hyoidei, the mylo-hyoidei, and anterior bellies of the digastrics divided, cutting from left to right, and from above downward.

The main part of the tumor was now detached, so as to be seized by the hand, and moved in different directions to facilitate the dissection. The masseter muscle was now dissected from the outer surface of the ramus as far as its attachments to the zygoma. The tumor was then carried forward and downward, in order to stretch the temporal muscle and bring it within reach; but the coronoid process ascended unusually high, and it became necessary to use the bone-forceps to cut through its superior portion, in order to liberate the attachment of the temporal muscle. By depressing and rotating the bone outward, the pterygoid muscles and dental nerve and

artery were put upon the stretch, and rendered more easy of division. The forefinger of the left hand was now made to pass along the inner and inferior surface of the ramus of the jaw, the two carotid arteries were felt and their position ascertained, as well as the insertion of the internal pterygoid upon the jaw. This muscle was divided by passing the knife close upon the bone from below upward, taking care to avoid the lingual nerve. The forefinger, carried still further upward, along the inner surface of the bone, reached the superior orifice of the dental canal, indicated by a bony projection, and the artery and nerve were now divided as they entered the canal.

The superior portion of the external carotid courses along at the distance of a quarter of an inch from the posterior border of the ramus, and at a point about a line below the notch which divides the coronoid process from the condyloid, and close to the bone forms the tripod of vessels—the transverse facial, the temporal, and the internal maxillary—previously alluded to. The transverse facial passes from its origin over the masseter, the temporal ascends over the root of the zygoma, as the continuation of the trunk, while the internal maxillary is applied immediately upon the inner surface of the bone, crosses its direction, and creeps along the inferior border of the external pterygoid muscle, indicating, from its position, that the temporo-maxillary articulation should be attacked from before backward and from without inward as the first step in the disarticulation.

The articulation being opened and divided in this manner, two-thirds of the tendinous insertion of the external pterygoid muscle were divided from above downward and from without inward, grazing the bone, and using principally the curved scissors. The operation was finished by a few cautious cuts with the scissors, and by rotating the bone so as to detach the mass by laceration of the remaining fibres around the joint. The internal maxillary artery, by this manœuvre, escaped cutting altogether, and thus a considerable source of inconvenience from hemorrhage was avoided.

The edges of the wound were now adjusted and maintained in place, along the line of incision, by interrupted sutures of silver wire. On the mesial line, where the incision made an angle in form of an inverted V, a suture was inserted on each side of the triangle, near the apex, incorporating

the tissues on the lower surface of the tongue with the integuments on the line of the incision. The tongue was in this manner held forward in the natural position, and prevented from falling back on the upper opening of the larynx. A few strips of isinglass adhesive plaster were placed between the points of suture; some charpie, a compress, and a light retentive bandage completed the dressing. The sutures were removed daily, beginning their removal forty-eight hours after the operation, and by the eighth day the whole line of the external incision was healed without any salivary fistula. The ligatures were all away by the fourteenth day. The side of the wound, within the mouth, healed more gradually, and a slightly astringent injection was daily used for cleansing and promoting the healing process.

The tumor, after removal, presented a globe-shaped mass, of which the portion of the bone most involved seemed to form part, as if the disease had originated from the centre of the osseous tissue. From one side of the tumor, across the greatest diameter, a part of the body of the jaw and the ramus were to be seen extending from the tumor to the condyle, the periosteum and ramus thickened, the condyle remaining healthy at the end of the mass; the part of bone where the first operation had terminated was found partly enveloped with the *tissu inodulaire* of the old cicatrix, and covered with some unhealthy granulations. The coronoid process was seen deprived of the part cut off by the bone-forceps during the operation. [*Vide* Plate IV., Fig. II.] The greatest diameter of the tumor extended from the side where the section of the bone had been made in the first operation to the last molar tooth of the right side, as seen in the plate. The anterior surface presented the triangular portion of integument resulting from the formation of the lower flap at this point. The lateral surface showed the external side of the body of the jaw expanded, and, like the inferior aspect, was rough and irregular from the dissection of the muscular attachments. The buccal or alveolar aspect of the tumor—the surface seen upon opening the mouth—presented a dense, compact mass, which filled the mouth, covered by the mucous membrane of the gums, thickened, and of pale maroon-color, firmly adherent to the morbid tissue below, and confounded with it. The alveolar edge was quite effaced, and along the original line of the teeth three large

molars and one small one were seen jutting out from the surface of the diseased mass. In cutting into the tumor from this surface a creaking sound was made by the knife, and a resistance was felt like that produced by incising into a scirrhous growth through the substance of which thin plates of bone are disseminated. The intimate structure presented, on the cut surfaces, a grayish-white fibrous mass, traversed by osseo-fibrous intersections filled up with striated cartilaginous material, from which, in some parts, an unhealthy granular liquid could be pressed. There was very little vascularity and scarcely any traces of vessels to be seen. The lingual nerve and the hypoglossal remained uninjured, and the sublingual and submaxillary glands were left intact, healthy, and in their natural place.

To the unaided eye, as well as to the microscope, this tumor revealed traits of a cancerous or malignant character. The patient, however, had a good recovery, and was able to leave her room for out-door exercise three weeks after the operation.

As was mentioned previously, the patient, when presented to me, besides the main tumor on the lower jaw, had on the side originally operated on a small growth, about the size of a walnut, apparently springing from the region of the spheno-maxillary fossa toward the origin of the external pterygoid muscle. Two months after the operation just detailed, by a careful dissection I removed this tumor, which partook of the same pathological character as the larger growth just described. This wound also healed kindly, and the patient, with the entire lower jaw thus removed, presented the same physiognomical traits as the patient represented in Fig. I., Plate No. III.

The physiologico-pathological effects were the same in both cases described, and represented in the drawings. The motion of the tongue remained, and the general and special sensibility also continued unimpaired. Voice, deglutition, and speech were not interfered with. The primary branches of the portio dura having been divided in front of the ear, the muscles under the influence of this nerve became paralyzed on both sides, and the countenance assumed an impassible and immovable expression. The lower eyelid failing to move toward the upper made it impossible to

close the eyelids, and the eye, from this cause, was easily suffused with tears. The branch of the fifth pair which joins and courses along the portio dura was divided with that nerve, and the dental branch of the fifth pair was also cut during the operation. The sensibility imparted to the integument through the influence of these last-mentioned branches became also modified after division. These functions, interfered with for a time, became gradually restored, as happened after the operation first described, taking place gradually and slowly through the restored innervation and the vivification of the nervous cicatrices.

I was assisted in this operation by several distinguished colleagues, and my life-long friend Professor Valentine Mott, the last surgical operation, I believe, at which he was present before his death, and in which he manifested as much interest as in the earlier days of his scientific triumphs. [*Vide* Plate IV.]*

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* Fig. I., indicating the line of incision, was taken some time before the operation, and is given at about one-fifth of the natural size. The patient persisted in closing her mouth while sitting for the photograph, hindering the inside view.

Fig. II. represents the pathological specimen, and is of natural size.

ON SHOCK AND COLLAPSE,

AND

THE PRIMARY TREATMENT OF INJURIES;

INCLUDING

THE CONSIDERATION OF THE TIME OF ELECTION FOR CAPITAL OPERATIONS REQUIRED AFTER EXTENSIVE LESIONS.

General Observations.—The treatment and management of the injured during the first few hours after severe lesions have been received, such as occur in railroad accidents or from wounds inflicted by projectiles on the battle-field, often decide the fate of the sufferer, and turn the delicately balanced scale in his favor, by the restoration of the vital powers, or, adversely, by their speedy annihilation. The overwhelming effect of a violent shock, profoundly agitating and disarranging every organ and function of the body, places the system frequently below the starting-point of spontaneous reaction, and without judicious and timely assistance the diminished vitality soon becomes extinguished. The authors who have written treatises on surgery seem to have passed over, with brief notice, the analysis of the pathological phenomena which follow upon great perturbations of the system from extensive external injuries. Until within a comparatively recent period the treatment applied to them has not been based upon precise principles deduced from the physiological facts connected with the chain of morbid phenomena which soon become developed after severe mutilations. No longer ago than the time of Boyer and his disciples it was the invariable custom, when an accident of serious character took place, to bleed freely in order to prevent anticipated inflammation, and while such practice may be advisable in many instances after reaction has been established, it is now

well understood that spoliative venesection would be the sure forerunner of disaster to the patient. In the works of Astley Cooper, of Abernethy, and other authorities of their time, we find only short notices on this subject; and even in the works of Velpeau, Malgaigne, Lisfranc, Nélaton, Syme, Liston, and Bilroth, the phenomena and therapeutic management of shock and its effects are only briefly commented on. The works on military surgery do not afford much more information on the subject, and in searching through the volumes of the *Leçons Orales*, delivered by Dupuytren at the Hôtel Dieu, of Paris, with all his great experience and means of observation, the matter is only cursorily spoken of. Articles scattered through the periodical literature of the last ten or fifteen years treat this subject with more accuracy and detail; but it is one of much importance, and admits of still farther consideration and investigation.

The term shock is used frequently as synonymous with collapse, probably from the fact that in some cases the effect follows the concussion so instantaneously that they appear to be identical. Shock may be regarded as the source of the nervous symptoms that take place after the occurrence of an accident, concussion being the first link of the chain of the consequent morbid phenomena; while the word collapse should properly be used to express the extreme prostration of strength and the agitation and perturbation of the nervous system which follow upon all severe injuries. If the word shock is at all applicable to general symptoms, it would be to accidents that are followed on the instant after the receipt of the injury by the suspension of vital phenomena or actual death, examples of which are found in the sudden deaths that sometimes follow a blow on the epigastrium, or the overwhelming effect of a fall from a great height, or in the mortal derangement occasioned by a shell or cannon-ball—injuries which admit of no appreciable sensibility after the fatal impression has been made. It is not possible here to trace the connection of one function giving way successively after another. Nothing is manifest but the immediate sequence of the cause, namely, the mortal effect. Here the impinging force or momentum and the effects show themselves so instantaneously that the source of the symptoms and the symptoms themselves—that is to say, the fatal disturb-

ance and its accompaniments—are apparently merged into one phase. Yet there must be an interval of time, although, perhaps, inappreciable and devoid of sentiency, between the initiatory concussion and the consecutive changes that follow, which changes terminate in reaction or in the immediate suspension of vitality.

Health and Disease.—The term health is used to denote the physiological condition of the body in which the functions are so well balanced that every action is in perfect harmony and regularity. In order that this state shall be maintained, the organs of circulation and respiration must be unimpaired, the nervous system act with sympathetic accuracy and exactness, and the character and composition of the blood, upon which the vital phenomena are dependent, must be normal. The deviations which occur in the performance of these functions constitute disease, and this may be brought about by whatever produces anæmia or hyperæmia in any of the parts or organs of the body, or whatever may pervert, increase, diminish, or alter the physiological impressionability of the nervous system to the influence of the blood. Other sources of disease originate in the vitiation of the blood itself, by the introduction of poisons directly into the circulation, either from inoculation or absorption of the virulent material, or from miasmatic and atmospheric agencies admitted into the blood through the medium of the pulmonic system.

These different agencies in the production of the changes which occur in the transition from the normal to a diseased condition seldom act alone, and, if so, but for a very brief period. One pathological phenomenon follows in quick succession upon the other, so that whether the first phase may have occurred from defective or excessive circulation of the blood in parts or in the whole of the body, or from injury or perverted susceptibility of the nervous system, or from direct admission of poisonous material into the blood, the general system is soon involved in universal commotion more or less violent, which ends in resolution or death. In the restoration to health the morbid symptoms gradually disappear, and the various functions resume their normal operations. But the progress toward death is not so easily followed, and should be studied and considered in order to meet

emergencies and to counteract the tendency toward dissolution in the different stages of collapse.

The Phenomena of Disease, and their Progress toward Death.—The different phenomena of disease which mark the gradual progress of the changes as they advance in succession toward death have been considered by various physiologists; but the investigations of Bichat, published in his *Recherches sur la Vie et la Mort*, did much to elucidate the delicate mysteries of approaching death, and the fundamental distinctions that he described as death beginning at the head, death beginning at the heart, and death beginning at the lungs, remain still as the nomenclature best suited to the consideration of this subject. Sir Benjamin Brodie and others have enlarged our knowledge in this direction by the numerous experiments made upon living animals, as well as by observations which they have recorded as seen upon man. In cases of shock which terminate fatally after the lapse of several hours, the initiatory steps toward dying commence with the reception of the external injury. Life is frequently extinguished after severe lesions by that mode of dying which is denominated asthenia, but in complex injuries the manner in which the different vital functions become finally exhausted is not always the same, the successive order in which the annihilation of the vitality occurs beginning from more sources than one. For example: A light-weight rider while training a colt was violently thrown. His foot caught in the stirrup, and he was dragged over the ground by the frightened animal. When picked up his skull was found to be badly fractured, and several ribs and one leg were broken. He died in a few minutes after he was rescued. Here we have, on the one hand, death beginning at the brain, the injury to which, extending to the medulla oblongata, paralyzed the muscles of respiration, while, on the other hand, the contusion and the fractures of the ribs and leg propagated their depressing effects through the spinal marrow and cardiac ganglion to the heart, annulling its action by the diminished supply of nervous influence which necessarily followed. Although the distinctions enumerated by Bichat may not be altogether sufficient, yet it is better to accept the arrangement he has offered as forming the most simple basis from which to start in considering the various

phenomena of disease in their tendency or progress toward dissolution. If the pathology of sudden death from external injury be now better understood, the explanations in given cases will be rendered more easy by having but few distinctive heads, yet sufficiently comprehensive, to which they can be referred. The vital organs—the brain, the lungs, and the heart—respond so rapidly and intimately to each other, and the performance of their functions is so closely dependent the one on the other, that it is in exceptional cases only that it becomes possible to study the different forms of dying in an isolated manner. In cases of severe limited injury, such as occurs from the crushing of a limb from a railroad accident, where the vital functions are suddenly stopped, or of poisoning by substances whose specific action is directed to an organ or set of organs, the progress to death may be traced to an insulated commencement. But the greater number of instances of external injury resulting fatally are examples of death proceeding from a complication of disturbing causes.

The distinctions, then, as laid down by Bichat, may be regarded as sufficiently comprehensive to enable us to analyze the phenomena of disease or of injuries in their tendency toward death, and to refer them to a primary source according to the lesion which may claim attention. Bichat probably took this view, and refrained from extending his fundamental distinctions to other organs, such as the stomach or the medulla spinalis, in order to render the explanation of the subject less complicated. While admitting the distinctive arrangement of Bichat as sufficiently ample or comprehensive, it cannot be doubted that since his time physiological investigations have much enlarged our information on the subject, and that the pathology of sudden death and of the different modes of dying is now better understood and more minutely described. At best, in the complex study of the various phenomena which tend to produce death, we have to seize upon some primary and important derangement and trace it to some given organ; and to accomplish this it will be found that reference to the brain, the heart, and the lungs will be abundantly full and precise.

When death is occurring from disease, as from fever of a grave type, a variety of pathological processes is usually at work at the same time,

which complicate the analysis of the phenomena that are slowly tending toward the destruction of the vital functions, although there may be a marked inclination toward one or other mode of dying, indicated by the particular organ or set of organs most deeply implicated. Thus, for example, we find in typhus the lungs sometimes become mainly affected during certain epidemics, while in others the brain or abdominal viscera are the principal organs associated with the febrile condition. In the extinction of life from external injuries, the advancing steps are often more distinct and more easily followed in their progress toward dissolution than in prolonged diseases; yet fearful lesions are inflicted by violence which complicate the mode of dying on account of the number of organs that become suddenly implicated and disturbed, as happens when the body and limbs become entangled in machinery, or when a heavy wall or embankment is precipitated with the rapidity and force of an avalanche on a group of laborers while at work. For a better comprehension of the subject in hand, and that the indications of treatment in collapse tending toward death may be clearly met, we may here take up in succession the consideration of the different modes in which life may be extinguished. Adopting, therefore, approximately the fundamental distinctions of Bichat, we may proceed to examine the mode of dying that begins at the heart, as this form very frequently presents itself in collapse from dangerous injuries.

There are two modes in which death commences at the heart: in one instance the heart is deprived of its natural stimulus, the blood, by the quantity reaching its cavities not being sufficient to maintain the necessary action; besides, the quality of the blood may be so devitalized as to be deprived of its stimulating characteristics. When the circulation thus fails, and the cavities of the heart do not receive the requisite supply of blood to induce its contraction, although the power to do so may remain, the term anæmia is used to designate the condition. Examples of death occurring in this manner are met with more particularly in cases where large vessels are wounded, as on the battle-field or in suicide where the large arteries are divided, in post-partum hemorrhages, or where large aneurisms become suddenly ruptured. In such or similar instances, in post-

mortem examinations, the chambers of the heart are found empty or nearly so, contracted, and not filled with blood, as happens in some other conditions about to be mentioned. The symptoms manifested in this mode of dying are often blended with those which follow severe shock unattended by hemorrhage. There is more or less insensibility, a fluttering, quick, and irregular pulse, obscure vision, pupils sometimes dilated, giddiness, cold and clammy surface, with pallor of the countenance and lips. There is also frequently great jactitation, with tossing of the limbs and body, with general restlessness and nervous delirium; if the sensibility be not too much annulled, there is nausea and vomiting, the respiration is irregular, the patient sighs and gasps, and finally death is ushered in by repeated convulsions.

The other form of death that begins at the heart is called asthenia, and depends on a loss of the contractile power of the heart from defective innervation, and not from a want of supply of blood. It is the most common form of death which follows collapse from the shock to the nervous system in severe external injuries where there is little or no hemorrhage. The experiments of Sir Benjamin Brodie have proved that the action of certain poisons also is to annul the nervous power of the heart, so as to arrest the circulation and destroy life; and here we have the post-mortem examination revealing that the cavities of the heart are filled with blood, the right cavities containing purple blood and the left scarlet blood. It may be here mentioned that syncope, a condition of suspended animation dependent on a failure of the circulation to reach the brain, is common to both forms of death commencing at the heart.

The mode of dying the commencement of which Bichat attributed to the lungs, is now very properly called apnœa* (ἀ priv., and πνεῖν, to breathe), which literally signifies "privation of breath." The term asphyxia (ἀ priv., and σφύζειν, to beat), signifying a want of pulse, was formerly used to denote this condition by a faulty nomenclature. The term suffocation is appropriately used to designate that condition which follows the abrupt obstruction of the entrance of air into the lungs by the interposition of

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* Vide *The Principles and Practice of Physic,* by Sir Thomas Watson. London.

some direct obstacle, or from paralysis of the muscles of the larynx, as may happen after a violent blow upon the box of the larynx. The immediate effects of the interception of the entrance of air into the lungs are met with in various forms of interrupted respiration, as in cases of drowning, of strangulation, of severe double pneumonia, of suspension of respiration from forcible pressure upon the chest and abdomen annulling the play of the diaphragm and intercostal muscles, and where there has been injury to the spinal cord in the cervical region above the origin of the phrenic nerve. In these and similar instances, where the air cannot have free entrance into the chest, there is a stagnation of blood in the lungs, inducing the circulation of venous or carbonized blood through the system, poisoning the brain, the spinal marrow, and the other parts of the nervous apparatus, and producing general impairment and extinction of the functions of life.

The pathology of the internal changes which take place in this mode of dying has been studied and described by Haller, Bichat, and others, and at a later date by Mr. Erichsen, of London. The fundamental source of the symptoms which occur is the lack of oxygen in the lungs, and the consequent absence of the normal change that should take place in the chemical composition of the blood. The blood in the pulmonic vessels becomes charged with carbonic acid, and, from the first, losing its proper stimulating influence, begins to circulate more and more slowly, ultimately becoming almost stationary or stagnant in the capillaries of the lungs. The blood remains venous, and in this state passes from the lungs through the pulmonary veins into the left chambers of the heart, and thence, by the aorta and its branches, through the different organs of the body. The blood, thus deprived of its vitalizing principle, and loaded with carbonic acid, is not suited or adequate to supply the proper stimulus to the organs it permeates, and reaching the brain and spinal marrow, the effects are soon manifested by jactitation, insensibility, and convulsions. The blood continues to flow more tardily and in smaller quantities into the left auricle and ventricle of the heart, producing but feeble contractions, owing to the deficient supply it receives. After death this side of the heart is found to contain but a small quantity of dark blood, while on the pulmonic or right side the ventri-

cle and auricle, with the contiguous *venæ cavæ*, are found to be distended with dark blood, and the general venous system to be filled and gorged with the same dark fluid.

The general symptoms occasioned by apnœa, or obstructed entrance of air into the lungs, when sudden, are marked by struggling efforts to effect respiration, by vertigo, insensibility, convulsions, twitchings or tremors of the limbs, and relaxation of the muscles and sphincters, while the action of the pulse becomes more feeble and fluttering, the heart continuing to beat for a short time after other signs of life have fled. When death comes more slowly, as in pneumonia or in croup, the respiration is labored and distressed, the countenance livid and leaden-colored, the eyes are turned up with the aspect of despair, and delirium is ushered in by the circulation of venous blood in the brain. In many cases, if the cause of the obstruction to the entrance of the air can be speedily removed, animation may be restored by the maintenance of artificial respiration. The blood, by degrees becoming oxygenated, begins to circulate through the pulmonary capillaries, reaches the heart and brain in the arterialized condition, and the impaired vital functions are gradually restored.

According to Bichat, another mode of dying is death commencing at the brain, and this is said to be death by coma. Examples of this occur from such injuries to the brain as produce compression sufficient to impress the medulla oblongata, and from certain poisons which, taken in toxic quantities, suspend the functions of the brain. Laceration of the middle artery of the dura mater, or of the vessels at the base of the brain, or the entrance of a bullet into the cerebral substance, produces coma which very frequently terminates in death. In such cases as these just mentioned, the immediate cause of death is similar to that which results from apnœa; but in those instances of injury which are preceded by compression of the brain, life becomes extinguished by the paralyzed condition of the respiratory muscles, which lose their power on account of the lesion of the nervous apparatus, while, in cases of apnœa, death takes place from the non-aerated condition of blood from interruption to the entrance of air into the lungs. In poison cases, such as result from opium, producing coma, artificial respiration may

be favorably resorted to, as in apnœa, to keep the lungs inflated and supplied with air, thus promoting decarbonization and the oxygenation of the blood until the coma shall have subsided. Coma is often associated with other modes of death arising from different primary causes. For example: If there exist a combination of fracture of the skull and depression, or of laceration of the middle artery of the dura mater, with, at the same time, extensive loss of blood from wound of a large vessel, resulting fatally, there will be death commencing at the brain—"coma;" and death commencing at the heart, from defective circulation of the blood—"anæmia." If to the above combination be added extensive injury, as from a railroad accident crushing a limb, there will be death occurring from coma, from anæmia, and from asthenia, these distinctive modes taking place almost simultaneously, and overwhelming the general system. Moreover, if in the same case an injury had been received on the body of the larynx, sufficient to paralyze the dilator muscles of the rima glottidis, or some influence destroying the action of the genio-hyo-glossi muscles, so that the tongue would fall back upon the upper orifice of the windpipe, the entrance of air into the lungs would be intercepted, and apnœa also would be the result, thus producing death from all the distinctive sources as enumerated by Bichat.

Anatomical Remarks.—From what has been stated it is evident that it is through the medium of the nervous system that the primary effects of injuries are communicated to the general animal economy. The heart and arteries are subordinate to the action of the grand sympathetic nerve and to its connections with the cerebro-spinal axis. When the blood becomes devitalized or contaminated by the admission of morbid or poisonous material into the circulation, so that the contents of the vessels in passing through the organs disturb the functions of life, the pathological results must still be referred to the morbific influence that is necessarily impressed upon a portion or the whole of the nervous apparatus. Sometimes the immediate result following the reception of a local injury—upon a limb, for example—is merely a greater or less disturbance of the functions of the parts on the distal side of the injury. An arm receiving a sudden blow may remain paralyzed or torpid for a considerable length of time. The paralysis while it

lasts may be complete, or the muscular or motor powers may alone be affected, the sentiency remaining undisturbed, or the sensation may be impaired while the other functions retain their integrity. More frequently, however, the impression of a severe injury is carried in a centripetal direction toward the great nervous centres. The painful sensations carried to the sensorium by the afferent cords are returned to the injured part by the efferent branches, and the remote sensations sometimes experienced, as well as the convulsive muscular spasm which often takes place after severe lesions, must be attributed to the reflex action of the medulla spinalis. The numerous commissures of the brain, and the continuous communication of the cornua of the gray matter of the spinal cord with the motor and sensory strands, as well as the interlacing of the filaments from the spinal nerves with those from the ganglions of the great sympathetic nerve, afford an explanation of the numerous complicated and distant sympathies which become manifested and developed after severe injuries. Although a local injury may be followed immediately by a torpid condition of the adjoining parts, amounting, in some instances, to muscular paralysis and effacement of sensibility, the morbid impression may rest confined or limited in its effects, and the system escape entirely from any sympathetic influence. Most frequently, however, a lesion of even moderate severity is very soon followed by constitutional symptoms of more or less gravity, generally indicating the extent of the injury inflicted, and the simplicity or danger of the impression received by the nervous system. Moreover, in different cases the extension of the primary effect of a severe lesion is radiated over the system in a variety of ways and in different grades of intensity.

Injuries that are followed by Shock and Collapse.—The injuries so severe as to be accompanied by shock, followed by collapse, and which ordinarily become the subject of treatment, may be, in the main, included in the subjoined category of lesions: severe contusions; extensive wounds; fractures of the large bones of various kinds; injuries that take place by machinery in factories; gunshot wounds; railway accidents, accompanied by violent concussion of the body, or by the crushing of a limb from the passage of the wheel of a railway carriage; injuries of the head,

with or without fracture of the skull; profuse hemorrhages; extensive burns, such as occur from steamboat and boiler explosions; injuries to the spinal column; surgical operations of magnitude; and dislocations of the large joints. To these may be added vivid mental emotions and their influences. Mental emotions undoubtedly destroy life by the overwhelming perturbation which they produce through the whole nervous system, death occurring most probably by the intensity of the effect becoming localized upon the cardiac ganglion and nerves, so as to paralyze the functions of the heart, while at the same time the blood becomes deteriorated and devitalized, as in cases of death following a stroke of lightning. This extreme result of psychological influence is, however, not common, although in many instances, especially in railway accidents and in gunshot wounds, and still more so in cases of suicide, the *morale* is greatly affected, and modifies to some extent the character of the symptoms as well as the final result.

General Symptoms.—As has just been stated, the influence of a shock following upon a severe injury may be trivial and limited in its effect, or it may be radiated over the system in the greatest degree of intensity. In describing the general symptoms of shock, a case of great severity must be supposed to exist which shall serve as a type of such accidents, and to embrace the signs characteristic of collapse in its gravest form. The symptoms of collapse are generally described *en masse*, as if they were all present at one time, and occurred simultaneously. This is not so, except in extreme cases, for they appear in succession, and run from a condition of stunning or partial torpor into a state of general insensibility, terminating in slow reaction or in coma and dissolution.

For example: A boy about twelve years of age, while playing on the platform of a railway carriage, the train being in motion, fell between the couplings of the car, and was run over, the wheels crushing the right leg a short distance below the knee. The train was immediately stopped and the boy dragged from under the wheels. I saw him at this moment, having just left the same train at the station where the accident occurred. He was pale, stupid, staring wildly, the lips livid, the surface beginning to get cold and leaden in hue, the pulse feeble and slower than natural, sensibility

diminished; could answer questions with difficulty, and monosyllabic when answering; complaining of no pain; respiration slow, feeble, and sighing. In this condition he was carried into the dépôt building and laid on a table, with the head low. The bleeding was stopped by a garrot tourniquet got up on the moment. There was some delay in procuring instruments before an operation could be performed, and during this period all the above symptoms gradually increased. The pulse became more feeble, so as to be scarcely felt at the wrist, the respiration was almost imperceptible, skin cold and clammy, the countenance and lips of leaden hue, torpor and complete insensibility, with coma—in fact, the boy appeared to be moribund. This patient recovered, after amputation, and will be alluded to hereafter, when speaking of the treatment.

Another case of a somewhat similar character presented itself to me, in which symptoms were present that were absent in the one just spoken of. An adult, about forty years of age, was run over by the wheels of a street car, and had the right leg crushed, breaking the bones, and lacerating the soft tissues in the upper third of the leg. I was requested to see him, and found him lying on the floor of a pharmacy, where he was taken immediately after the accident. He was under the influence of spirits at the time of its occurrence. He answered questions wildly; was restless; sick at the stomach, vomiting at times; countenance stupid; pulse feeble and rapid; respiration irregular and feeble; although suffering from the shock, he was not insensible or comatose. His house was at the distance of two miles, along the course of the street cars, and his friends desired that he should be placed in a car and removed to his home. This was accordingly done. A tourniquet was applied over the femoral artery, but, from the jolting of the car, some oozing of blood took place during the transfer. Upon reaching home the tourniquet was tightened, and he was placed in bed; but by this time—a period of about an hour—the symptoms had all become aggravated. The pulse had increased in rapidity and feebleness, the respiration was rapid, irregular, and sighing, the restlessness had turned into jactitation, and the nausea into increased recurrence of the vomiting. There was great tossing of the body from one side of the bed to the other;

hawking and spitting ; irrelevant, vulgar, and disconnected sentences, spoken quickly and with irritability. The insensibility increased, with a death-like coldness and clamminess of the surface. This condition soon passed into entire insensibility, convulsion, and coma ending in death.

Here we have two cases occurring from lesions very similar in character and extent, yet in neither case were all the possible symptoms present. This may be so, however, and every symptom previously described become manifest between the occurrence of the shock and the termination in reaction or death. The difference between these cases was probably that in one more blood was lost immediately after the accident than in the other. The instance given of the light-weight rider who was thrown so violently that he fractured the leg, several ribs, and the skull, embraced almost every possible condition; but in that, as in most instances where such violent injuries are received, he was killed outright.

Collective Symptoms.—The collective symptoms ensuing upon severe shock may be given as follows: torpor; stupor; rigor; pallor, and leaden color of countenance; cold sweat and clammy skin; anxiety; hurried breathing; restlessness at times, at others complete lethargy and inability to be roused; pulse feeble, sometimes rapid, intermitting, and fluttering, at others scarcely perceptible at the wrist; sickness, nausea, and vomiting; glazed eye, with stupid expression and incoherency; respiration feeble, sometimes rapid and irregular, sometimes slow and stertorous, or scarcely perceptible; syncope; delirium; great thirst; suppression of urine and suspension of secretions; insensibility; coma; often spasms; tremors; convulsions; jactitation; and contraction or dilatation of pupils. There have been instances known in severe railway accidents, in steamboat explosions, and from causes of like severity, where the concussion to the general system was so profound that though the patient, for some minutes after the accident, conversed, or even walked about without apparent injury, suddenly fell dead. In such instances of unexpected and unlooked-for cessation of the functions of life, the suddenness of death is most probably caused by the rapid devitalization of the blood, resulting from the desperate character of the injury, inducing such condition as is met with at times in typhus ambulant and in some

abruptly fatal cases of yellow fever, although in these maladies the disintegration of the circulating fluid progresses more slowly. This obscure and illusory condition, fraught with insidious danger, and indicated only by negative signs, is apt to be overlooked, or not considered to belong to the previous category, which it strictly does, being a species of collapse, following shock, where the injury has been so great as to paralyze all the organic functions.

Etiology.—Previous to the last half century it would not have been possible to have comprehended or explained the pathological phenomena following immediately upon the receipt of a severe injury, for the reason that at that time the anatomy and philosophy of the nervous system were not sufficiently understood. The discoveries of Charles Bell, of Magendie, Longet, Claude Bernard, Brown-Séquard, and the experiments of Marshall Hall and others, have opened up a new field in this direction, and afforded explanations of numerous morbid manifestations, both in internal and external pathology, which were not comprehended previously. The physiological divisions, histology, and general properties of the nervous system have also been studied more carefully. The earlier writers seem to have been aware of the peculiar characteristic of the nerves which enables them to conduct to and from the great centres the impressions through which we become cognizant of the existence of external agencies. The important facts elucidated by the experiments of Charles Bell and of Magendie, localizing the distinct seat of the motor and sensory properties of the spinal nerves, proved to be the starting-point of many other disclosures in connection with the physiology and functions of the cerebro-spinal system. Following upon the important fact that the anterior roots of the spinal nerves are endowed with motor power, and that the posterior roots are exclusively sensory, came, as if by analogy, the partition of the functions of the cranial nerves into those of motion and into those of special and general sensibility. Putting to one side the nerves of special sense, as the olfactory, the optic, and the acoustic, the gustatory branch of the fifth pair and a part of the glosso-pharyngeal, we have the motor cranial nerves, viz.: the third pair, or motores oculorum communes; the fourth pair, or pathetici; the sixth pair, or motores externi;

the nerve of mastication, from the small root of the fifth; the seventh pair, or portio dura, the nerve of expression, with the intermediary nerve of Wrisberg; portions of the eighth pair and of the spinal accessory; and the ninth pair, or hypoglossal: while as the sensory cranial nerves we have the large root of the fifth pair, or trifacial; part of the second division of the eighth pair, the pneumogastric; and the sentient part of the glosso-pharyngeal. The pneumogastric and spinal accessory are almost from their commencement joined by various nervous branches, and early in their course become nerves of mixed character. Besides the action of the medulla spinalis as a great nerve centre, we find that it is composed of white and gray nervous matter, the fibres of the white matter, in conjunction with the gray substance of the cord, acting as co-ordinators and conductors of sensory impressions from the periphery toward the centre, while the gray matter forms a connected chain of ganglia which act as a congeries of nerve centres, receiving impressions and generating the so-called *vis nervosa*, and with the antero-lateral columns of the cord serving, to a greater or less extent, as a conductor of motor influence from the centre to the periphery.

The medulla spinalis, taken as a whole, with its antero-lateral and posterior columns, presents numerous commissural connections and decussations along its anterior portion, most plainly distinct at the medulla oblongata, and also along the posterior portion almost throughout the whole extent of the cord. The cord also contains the elements of the important function of "reflex action," and, in conjunction with the grand sympathetic, the vaso-motor influence upon the blood-vessels. Thus we have the medulla spinalis and medulla oblongata affording the basis of explanation of many of the phenomena following severe external injury. Impressions from the periphery are conveyed through the posterior roots to the cord, and conducted onward to the brain, while the stimulus generated by the encephalic nervous centres is conveyed centrifugally from the brain, and passes from the cord along the anterior roots of the spinal nerves toward the periphery—reflex action and the vaso-motor influence, referred to before, acting their part separately or in combination. The commissures and points of decussation in promoting the reciprocal action of different portions of

the nervous system must not be overlooked. Following up the nervous connection, we have the cerebral ganglia at the base of the encephalon as well as the cineritious matter of the cerebellum exerting their influence upon the organs of special sense. The perturbations after severe lesion conveyed along the spinal cord, passing through the medulla oblongata, the pons varolii, the crura cerebri and cerebelli, the optic thalami, and the corpora striata, are radiated directly upon the gray matter of which the encephalic ganglia and convolutions are composed, and are thence transmitted and distributed over the whole or a part of the nervous system.

The several points of decussation of the fibres across the median line from one side to the other, and the large and small commissures, act also in promoting the dispersion of the morbid or baneful effects of shock.

The grand sympathetic system of nerves comes in also to play a part in the general disturbance or upsetting of the normal functions. The cerebro-spinal axis thus intimately connected in its various parts is equally in close communion with the organic set of nerves by the anastomosing net-work that exists between the branches of one class and those of the other, from the cephalic ganglia at the head to the ganglion impar near the coccyx, the last of the thirty-two or thirty-four ganglia of the sympathetic. These branches of communication between the sympathetic and the cerebro-spinal nerves exert a marked and pervading physiological influence over all the organs of the body, and when disturbed become large participators in the development of the symptoms associated with collapse. From this cursory glance at some of the functions of the nervous system, it is very evident that we must learn through it the interpretation of most of the symptoms that take place as the immediate effects of severe injuries from external causes. Without running the theory too far, it may be said that nearly the whole range of disease appears to commence by a species of shock reverberating and undulating over the nervous system. What else can be said of the influence of malaria, or a poisonous atmosphere contaminating the blood and bathing the nervous system, in the production of intermittent or malarial fever? We have the initiatory cause leading to collapse, manifested by the cold stage, followed by the reaction. In yellow fever, in typhus, in poison by

the bite of a venomous serpent, in the exanthemata, and in the sudden effusion of blood in cerebral apoplexy, we have a cold stage initiating the reaction which follows if the system be not overwhelmed by the primary shock.

Physiological Mechanism and Analysis of individual Symptoms following Shock.—The rate at which nervous conduction progresses in the human subject in the sensory and motor nerves is estimated at about one hundred and eleven feet per second. Between the time of the receipt of a severe injury, the shock, and the commencement of the manifestations, or of the symptoms of collapse, there is consequently an appreciable space of time, although necessarily of brief duration. It is difficult to designate the minute pathological changes which are so suddenly radiated over the system.

The explanation of the several symptoms which are manifested successively after the infliction of severe external injury follows to a great extent upon the comprehension of the mechanism heretofore sketched.

Torpor, Stupor.—Torpor, stupor, partial insensibility, and general prostration supervene almost immediately, and can be accounted for by the disturbance of the general nervous system, which is the immediate sequent to the shock. The injury inflicted upon the nerves at the seat of lesion is transmitted and radiated over the entire telegraphic communication of nervous cords, centres, and ganglia, modified by commissures and the several points of decussation, and multiplied by the excito-motor and vaso-motor influence. In many instances the fundamental or intimate nature of the pathological changes which take place after shock, as in the pathological conditions of some forms of insanity, of epilepsy, and of catalepsy, has so far eluded the examinations of histology, of chemistry, and of the microscope.

At the moment of the receipt of the shock the fibres of the white substance or the cells of the gray matter may not be appreciably changed within the scope of the present means of exploration; but, whether from electric influence or otherwise, a great perturbation takes place, and the very principle of life seems to be attacked and overwhelmed for the time. The essential nature of the nervous fluid or force—the imponderable agent by which the operations of the nervous system are carried on—is not solved in our present state of information, and may be said to be the ultimate cause

of certain characteristic phenomena. It has been claimed by some physiologists to be identical with electricity, but the experiments made by Prévost and Dumas in 1823, and later by Matteucci and Longet, appear to disclose facts that are opposed to this hypothesis, as they failed to démonstrate the existence of a true electric current in the nerves in action. According to Cuvier, it is by or through the agency of an imponderable fluid that the nerves act; that all the animal fluids being drawn from the blood by secretion, there is no reason to doubt that the nervous fluid does belong to the same category, or that the medullary substance does secrete it: "Il y a grande apparence que c'est par un *fluide impondérable* que les nerfs agissent.....tous les fluides animaux étant tirés du sang par sécrétion, il n'y a pas à douter que le fluide nerveux ne soit dans le même cas, ni que la matière médullaire ne le sécrète.....les fonctions nerveuses, c'est-à-dire, la sensibilité et l'irritabilité musculaire, sont d'autant plus fortes dans chaque point que leur agent y est plus abondant; et comme cet agent, ou le fluide nerveux, est produit par une sécrétion, il doit être d'autant plus abondant qu'il y a plus de matière médullaire ou sécrétoire, et que cette matière reçoit plus de sang."

Longet gives the following *résumé* in relation to the hypothesis regarding the identity of the nervous fluid with electricity:

"1. Il n'existe, jusqu'à présent, aucune preuve directe et certaine en faveur de l'hypothèse des courants électriques dans les nerfs.

"2. L'électricité et la force nerveuse ne sont point identiques.

"3. Dans l'état actuel de la science, il y a témérité à affirmer qu'ils sont *totalement* différents, et qu'ils n'offrent pas la moindre analogie.

"4. Le névrilème, qui transmet de faibles courants électriques, ne peut transmettre le principe nerveux.

"5. L'électricité n'est probablement qu'un simple excitateur de la force nerveuse persistante, et son action doit être assimilée à celle des irritants mécaniques ou chimiques."

The theory that the nerve cells of the gray or ganglionic matter generate nerve force, and that the white strands and cords conduct from the nervous centres to the periphery the force or influence thus generated, seems to be

the most reasonable, and serves to explain more satisfactorily than any other hypothesis the various symptoms which follow upon severe shock to the general system. With the supposition that the gray matter of the ganglia and of the encephalic convolutions secretes the nervous fluid, it can be well understood that the cessation or interruption of this secretion would be followed by systemic disturbance.

The question is now definitively settled by positive experiment that the sensory nerves and posterior columns of the medulla spinalis convey impressions from the periphery to the nervous centres, and that the antero-lateral columns and the anterior roots of the spinal nerves transmit the motor stimulus from the centre toward the circumference, and also, that through the agency of the excito-motor mechanism impressions are transmitted to the nervous centres, and again from them reflected in a peripheric direction upon the different portions and organs of the body. Let us take, then, a patient with a limb shattered by a cannon-ball or shell, or a patient with the lower extremity crushed below the knee from the passage of the wheel of a railway carriage—in the latter case the bones broken and comminuted, the muscles, arteries, and nerves divided and crushed, and the lower portion of the member hanging by loose shreds of cellular tissue, fascia, and contused ecchymosed skin to the upper portion. In both of these instances the morbid impression from the local injury is transmitted along the nervous trunks to the medulla spinalis, thence along the medulla oblongata through the cerebellar and cerebral crura and cranial ganglia, to reach, by means of the radiating white nervous fibres, the gray matter of the cerebral and cerebellar convolutions. The morbid impression thus impinging upon the gray matter destroys, to a greater or less extent, the power of secreting the nervous fluid by its proper organ or tissue. The nervous strands and cords, on the other hand, whose function it is to transmit the nervous stimulus toward the general periphery, are no longer supplied by the proper active principle of the nerves, and thus the tissues and the organs one after another give indications of disturbance, or cease to perform their accustomed functions. In addition to this train of action, the chemical relation of the blood corpuscles becomes deranged, the electric balance of the blood disks is

disturbed, and the blood itself becomes devitalized. While this general perturbation is progressing, other symptoms become manifested which admit of a more detailed and minute analysis. In connection with what has just been stated, another important fact must also be mentioned. The nerves of general sensibility and those of motion are entirely distinct at their origin at the cord, but beyond the intervertebral ganglia, and as soon as they have emerged from the vertebral canal, they become united in a common envelope, and thenceforth become mixed nerves. Some of the cranial nerves have a similar general disposition of sensitive and motor roots, such as the fifth pair, the seventh, the eighth, and soon after their origin become nerves of mixed character. The result of this arrangement is that each of the spinal nerves and some of the cranial, with their branches, partake at the same time of the characters appertaining to the nerves of motion and of sensation, and when directly excited cause pain and local contraction. Moreover, the branches of the rachidean and cranial nerves, after their emergence from their respective ganglia, receive branches of anastomotic communication from the ganglia of the grand sympathetic nerve along its entire extent. The mixed nerves are thus in direct communication with the nervous columns of the medulla spinalis, which receive and transmit impressions to and from the great nervous centres.

The psychological manifestations, such as fear and panic, produced by shock are brought about by a nervous mechanism similar to that which causes those impressions that take their origin from the common sensory and motor nerves of the medulla spinalis and encephalon. The sensations transmitted to the brain from the seat of injury serve as a stimulus to the emotional part of the brain, and from this ganglionic medium are reflected upon the excito-motor system of the cerebro-spinal axis, throwing the muscular apparatus of the body into tremor and involuntary convulsive action. It is probable that the intellectual and affective portions of the brain, when under certain conditions of activity incited by external impressions, may also become the seat from which is radiated upon the excito-motor apparatus the stimulus that produces the manifestations of reflex action upon the general system.

There are certain physiological laws which regulate the transmission of the nervous fluid in health that are also applicable to the nervous system when thrown into a pathological condition. Putting aside the peculiar action of the excito-motor function, it is necessary, in order that sensation shall be perceived and voluntary motion produced, that the sensitive nerves and the motor nerves remain in communication with the encephalon, either directly, or indirectly through the medium of the medulla spinalis. Nervous impressions are carried toward the nervous centres centripetally, like the current in the veins toward the heart, while the impressions which transmit the principle of movement, like the blood in the arteries, pass in a peripheric or centrifugal direction. When the sciatic nerve, for example, is divided, and the free end of the distal portion irritated by mechanical or galvanic excitation, no sensation will be produced, but the muscles supplied by branches taking their origin below the point irritated will be thrown into contraction, while, on the contrary, the free end of the proximal portion, which remains in connection with the cerebro-spinal axis, under the same stimulus, will evoke sensations in all the parts where its nervous filaments are distributed, but no appreciable signs of motor influence will be evinced. The ulnar nerve struck at the elbow between the olecranon and the epitrochlea transmits directly and at once, through the nervous filaments which take their origin below the seat of injury, a disturbed motor influence upon the muscles to which these filaments are ramified. The sensation of pain, referred to the part where the blow was received, and along the ulnar side of the ring finger and both sides of the little finger, is transmitted to the sensorium first, and returned upon the remote parts by nervous communication, travelling, as previously mentioned, at the rate of one hundred and eleven feet per second to and from the sensorium, before sensation can be perceived.

A similar principle of action is revealed when the galvanic stimulus is applied upon the medulla spinalis still united to the encephalon. Having cut the entire cord transversely, it is found that the galvanic stimulus, applied upon the caudal extremity of the posterior column, produces no sensation, but applied upon the cephalic segment, exquisite sensibility is the result. The same irritant applied upon the antero-lateral column in the cephalic

section produces no evidences of sensation, but violent contractions in the muscles of the pelvic extremities are the immediate effects.*

Prochaska and Legallois first made known, and Marshall Hall still further developed the fact by experiment, that the medulla spinalis and medulla oblongata, besides other functions, possessed the characteristics of a distinct and independent nervous centre, and that when separated from the encephalon they could still remain the seat of peculiar and remarkable phenomena.

The reflexion which takes place from the sensitive nerves upon the motor nerves through the intermediate agency of the medulla spinalis and medulla oblongata, considered as indispensable centres, is described by Marshall Hall as automatic, or altogether independent of volition. This author confines the function of reflex action solely to the rachidean nerves, and excludes the nerves of the encephalon, asserting that what is termed reflex action is never provoked by a sensation. Herbert Mayo, and after him Muller, however, regard the theory of reflexion that takes place from the cranial sensory nerves upon the motor nerves through the intervention of the encephalic masses as applicable to all the automatic movements which take place after various sensations. The panic-stricken criminal receiving sentence of death is an instance of this. The sound of the judge's voice undulating upon the acoustic nerve produces impressions that are transmitted to the emotional part of the gray matter of the brain, from which they are radiated upon the cranial motor and rachidean nerves, producing trembling and involuntary contractions of the whole muscular system. Even brave men have been struck with this involuntary trembling upon going into battle for the first time, the series of sensations commencing with the boom of the yet distant cannon.

In view of the facts just stated in relation to the laws which preside over the transmission of the nervous fluid, it may be concluded that the

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* When in Paris, several years since, I had the privilege of assisting at numerous vivisections, performed by M. Longet, in illustration of this part of the physiology of the nervous system. Some of these experiments proved conclusively that the gray matter of the brain generates the nervous principle or fluid, and that the white matter has the mission of serving as the conductor, the gray matter alone giving the character of nervous centre to the medulla spinalis.

immediate effects of a severe injury upon a part where the nerves are of mixed character, as upon a limb, will be of a duplex nature. The motor filaments supplying the parts below or beyond the seat of injury will be directly affected so as to produce local spasm or more or less loss of muscular power, the nervous influence manifesting its perturbation centrifugally. On the other hand, the nervous sensory filaments will act on the proximal side of the injury centripetally, and transmit the impressions from the seat of lesion along the nervous trunks to the spinal cord, and thence to the nervous centres. From these will emanate all the various complex phenomena which are radiated over part or the whole of the system by nervous communication, and by reflex action producing in the aggregate the symptoms of collapse.

As the ganglia of the great sympathetic are supplied by sensory and motor filaments, it is probable they are also endowed with the power of reflex action, and that this system acts an important part in producing the symptoms of collapse in those injuries which are attended by severe succussion or jar to the body without other evidences of lesion.

The effects of extensive external lesions are modified by the severity and intensity of the impressions conveyed to the nervous centres, and the consequent total or partial suspension of the secretory function of the cells of the gray matter. Thus we may have the shock of so severe a character that vitality becomes extinguished; or, on the other hand, if the intensity of the impression be of less severity, the secretory function of the nerve centres is only partially suspended, and we have shock followed by collapse, which may admit of healthful reaction, and recuperation of the disturbed and depressed organs. Taking for granted the hypothesis that attributes to the cells of the gray matter the power of secreting the nervous fluid from the blood, as the bile is secreted from blood in the liver, we can easily understand that in proportion as the nervous fluid fails to be produced or generated, and is no longer conducted along the nervous cords, the function of one organ after another must necessarily become to a greater or less extent altered or suspended. Torpor, stupor, delirium, coma, loss of intelligence, of sensation, and of motion, necessarily follow as sequents upon the

paralyzed function of the gray matter of the medulla spinalis and of the encephalic ganglia and convolutions.

From apparently opposite conditions, although in reality the same, torpor, stupor, coma, and delirium can also be produced from excessive loss of blood, as is seen in cases of profuse hemorrhages occurring from wounds of large arteries, or from destructive uterine hemorrhage during and after labor. The brain and spinal marrow cease to receive the necessary amount of the proper stimulus, and from the shock to the system which supervenes, and through the same net-work of nervous communication, a series of symptoms occurs similar in character to the collapse which results from extensive injury, whether the lesion be from a crushed limb, an extensive burn, or a fractured skull with depression of bone. Syncope takes place. The system may react, or, with the continuance of the cause, vitality becomes extinct.

Nausea, Vomiting.—Other organs are reached through the medium of individual nerves, and manifest their sympathy by signs of morbid perturbation. The stomach, under the influence of the pneumogastric and of the semi-lunar ganglion and coronary plexus, after certain injuries, shows signs of commotion by the interruption of digestion, by nausea, retching, and vomiting. The nervous communication is traced, in case of injury to the soft tissues of the neck or to the thoracic or pelvic extremities, from the seat of lesion to the medulla spinalis, medulla oblongata, and brain, thence along the par vagum to the stomach. In injury to the brain itself, the perverted nervous influence is conveyed from the cephalic cineritious centre more directly along the par vagum; while if the trunk is the principal seat of lesion, as from extensive scalding from boiling water or steam, or from violent succussion, the morbid impression is transmitted along the thoracic and abdominal spinal nerves and the corresponding ganglia of the sympathetic to the medulla spinalis, to be ultimately radiated thence along the greater and lesser splanchnic nerves to the solar plexus, the semi-lunar ganglion, and coronary plexus upon the stomach. In some cases of severe general injury, the influence of the shock may be transmitted simultaneously through all of these various communications, perturbating or destroying the functions of the main organ of digestion.

The Heart and the Circulation.—The heart and arteries enact so essential a part in the animal economy, and are so freely supplied with branches and filaments from the several classes of nerves, that they are necessarily in the highest degree susceptible to impressions resulting from injuries received upon any part of the body. The abundant supply of nervous agency, which invests the central organ of the circulation with such important qualities, affords it an amount of vitality that apparently renders it to a certain extent independent of the cephalic and spinal nervous centres. It is well known to physiologists that the whole of the encephalic mass, with the exception of the medulla oblongata, can be gradually removed without directly destroying the action of the heart; yet, at the same time, it is so easily affected that its movements may be arrested by a sudden and intense psychological or physical impression originating in the brain, or transmitted from the seat of an external injury to that organ, to be thence conveyed to the heart by the pneumogastrics. In fact, so great is the inherent vitality of the heart, that it can be actually cut out from the body, and still continue to contract, and to retain for a time its irritability and impressionability to mechanical and galvanic stimuli. With an organ so constituted and with such numerous relations, it might be inferred that a severe shock would produce great disturbance in the performance of its normal functions, and that the anatomical arrangement through which the various nervous impressions are conveyed should be of a complex character. The heart is supplied with nervous influence through the cardiac nerves of the great sympathetic, the cardiac nerves of the pneumogastric, and from branches of the spinal accessory. The sympathetic cardiac nerves, three in number on each side, are derived from the three cervical ganglia, and form, with the cardiac nerves of the pneumogastric, the deep cardiac plexus. The superficial cardiac plexus, which lies beneath the arch of the aorta, is formed by the left superior cardiac nerve, the left inferior cardiac branch from the pneumogastric nerve, and filaments from the deep cardiac plexus. From the cardiac plexuses emanate the anterior and posterior coronary plexuses, the branches of which are distributed, as their names imply, to the surface and substance of the heart with the branches of the anterior and posterior coronary arteries. In

addition to the coronary plexuses, recent dissections have demonstrated that besides the ganglion of Wrisberg, in the superficial cardiac plexus, there exists a dense net-work of nerves, upon which are found numerous ganglia, the branches of which are distributed to the surface and muscular substance of the heart. These organic nerves are derived from the six cervical sympathetic ganglia, and from the superior thoracic ganglion on each side, thus making in all eight masses of gray nervous matter, which, if united into one ganglion, would form an aggregate of cineritious material as large as the entire nervous system of some of the articulata, or even of some of the inferior vertebrata.

In some of the animals placed low in the zoological scale almost the entire nervous apparatus upon which vitality depends is composed of the organic or sympathetic class of nerves. It can thus be understood that the heart may play the part of a separate existence, and although connected with the cerebro-spinal system, may, notwithstanding, perform functions inherent to itself, and entirely independent of the nervous supply that it receives from the division of the nervous system to which the functions of animal life more particularly belong. But these organic functions, vastly important in themselves, like the centrifugal force in mechanics, to be of use, must be governed and regulated in order to bring about their harmonious action. Admitting that the grand sympathetic supplies the organic sentiency which renders the heart susceptible to the stimulus of the blood, and by which its contractions are produced, other agencies are needed through which different manifestations, such as continuous regularity of action and of force, take place, both of which are sustained in the normal condition of the organ. The pneumogastric nerve comes in here to supply the want. This nerve is exclusively sensory at its origin, but, emerging from the cranial cavity, it receives motor filaments from several nerves which become joined with the trunk, and is converted into a mixed nerve. By the addition of motor influence derived more particularly from the communicating branch of the spinal accessory, the heart becomes endowed with muscular tonicity, and, through reflex action, with the co-ordinate influence that presides over the regularity of its movements. The heart, which under the influence of the

sympathetic alone would act without order, assumes rhythmical regularity and force under the agency of the pneumogastric. Division of the pneumogastric nerves in the neck is not followed by stoppage or arrest of the action of the heart, as might be anticipated, but by acceleration of the number of pulsations and diminution of force. After the section, powerful galvanization of the extremity of the nerve in connection with the heart paralyzes the motor filaments of the trunk, and arrests the action of the heart, which remains in diastole and flaccid while the current is kept up. From these experimental facts, the solution may be obtained of certain manifestations of irregular, rapid, and tumultuous cardiac action taking place apparently from nervous exhaustion and perturbation of the pneumogastrics at their origin and along their course, whether resulting from disease or from external lesion. This symptomatic condition of the heart is often met with after severe traumatic injuries, or during the initial stages of organic disease of important organs, such as the heart, liver, or kidneys, and indicates the existence or commencement of a general deterioration of the vitality of the system.*

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* This erratic condition of the heart, caused by exhaustion and disturbance of the nervous supply, and associated with the phenomena alluded to, has not received the attention its importance would indicate, and the rationale of the symptoms has not been intelligibly given. It has been best described by Bouillaud in his *Traité Clinique des Maladies du Cœur*, is often met with in surgical practice, and is probably of similar origin to the peculiar state of the system, and of the heart and circulation, defined by the late Mr. Travers, in his work on *Constitutional Irritation*, as "prostration with excitement," occurring as a sequence of external injuries followed by collapse. Bouillaud describes as follows the action of the heart alluded to: "Il est des cas où les battements du cœur se succèdent à des intervalles de durée inégale, et tantôt ces battements se font tous avec la même impulsion, tantôt au contraire, avec une impulsion inégale. Cette irrégularité, cette véritable ataxie, cétte sorte de *folie* des battements du cœur, si j'ose me servir de cette expression, coincide ordinairement avec des intermittences plus ou moins fréquentes: rien n'est véritablement comparable au désordre tumultueux, à l'étrange confusion qui règne alors dans les battements du cœur. Cet organe nous offre, dans ce cas, l'image d'une machine complètement dérangée et tout à fait démontée; toutes les lois qui régissent ses mouvements, si bien réglés, comme nous l'avons vu, à l'état normal, sont bouleversées; et si je ne craignais d'abuser ici du style figuré, je dirais qu' à l'ordre établi par les lois de la nature elle-même, a succédé le plus complet état d'anarchie. J'ajouterai que l'espèce de trouble que nous signalons est, jusqu'à un certain point, pour les fonctions du cœur, ce qu'est pour les fonctions du cerveau le délire, l'aliénation mentale; et de là l'expression métaphorique de *folie* dont je me suis servi plus haut.

"Les irrégularities du cœur que nous venons de mentionner, et dont on ne peut se faire une juste et complète idée qu'en les observant soi-même, se partagent en deux espèces distinctes: dans la première espèce, le désordre est tel, que non seulement le rhythme normal du cœur est *dérangé*, mais que chacun des battements entiers et complets de cet organe diffèrent de ceux qui le suivent comme de ceux qui l'ont précédé. Dans la seconde espèce, au contraire,

The central organ of circulation is supplied so profusely with organic and involuntary motor power derived from the grand sympathetic, that it possesses in an unusual degree the characteristics of individual and inherent vitality, somewhat analogous to that of those animals that have the rudiments only of a cerebro-spinal system, and depend for their existence mainly upon the agency of the organic nerve centres. It is principally through the influence of this class of nerves that the automatic movements of the heart take place under the stimulus of the blood. But the movements of diastole and systole require to be regulated, and the pneumogastrics execute the mission of restraining these movements, so as to place them under the rule of rhythmical order. Besides, a nerve has lately been described by Cyon and Ludwig, which is formed by a branch from the superior laryngeal nerve and by one from the trunk of the pneumogastric, which passes downward along the neck, and joining in the chest with filaments from the sympathetic, reaches the heart between the pulmonary artery and the aorta, and is distributed to its muscular tissue. Experiments made upon this nerve seem to prove that it possesses, under excitation, through its reflex action, a decided depressing influence upon the action of the heart, and from this it has been called the depressor nerve of the circulation. It will thus be seen that the central organ of the circulation is freely supplied with organic sensory and motor branches from the sympathetic, the pneumogastric, and the communicating branches of the spinal accessory, and that the numerous nervous filaments which are distributed to the heart are of a mixed character, and place the organ in communication and correlation with the cerebro-spinal axis, as well as with the nerve centres of the ganglionic system. It

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les irrégularités se succèdent régulièrement, si l'on peut ainsi parler, c'est à dire qu' à chaque battement complet du cœur en succède un autre qui lui ressemble: en sorte qu' il reste encore ici quelque trace de cette tendance à la suprême loi de l'ordre, qui éclate de toutes parts dans le gouvernement de l'économie vivante. Disons enfin que les deux espèces d'irrégularités peuvent quelquefois se succéder chez un seul et même individu, à des intervalles de temps plus ou moins éloignés".....

....."Si l'on nous demande maintenant quelles sont les conditions morbides sous l'influence desquelles apparaissent les différentes aberrations du rhythme des battements du cœur, nous répondrons, sans entrer dans des détails qui seraient déplacés ici, que tantôt elles sont purement *dynamiques, nerveuses, vitales,* et que tantôt, au contraire, elles coincident avec de graves lésions *organiques,* soit aiguës, soit chroniques."—*Traité Clinique des Maladies du Cœur, par J. Bouillaud, Professeur de Clinique Médicale à la Faculté de Médicine de Paris,* etc.

would be the work of elaborate physiological investigation to designate and separate the properties and exact functions of each distinct kind of nerve in the various pathological and healthy actions of the heart. Investigations and experiments on this portion of the nervous system sufficiently prove that the heart, for its movements, its muscular tonicity, its force, its timbre, and rhythm, is greatly dependent upon the diversified sources of its nervous supply, and that when the pre-established harmony and balance of nervous power between the several classes of its nerves become interrupted or destroyed, perturbation and tumult in the performance of its functions will necessarily take place. The inherent independence of the heart, however, in the performance of its movements, is certainly remarkable. Experiments made upon cold-blooded animals, where the irritability of the tissues remains for a considerable time after death, prove that it will pulsate after the cavities are emptied of blood, and also, that in a vacuum, when removed from the stimulus of the air, or when exsected from the body, and thus cut off from all connection with the general nervous system, it will continue to contract. Upon the application of a stimulus, such as the point of a needle, contractions will still take place after the animal has been poisoned by woorara, which is known to paralyze the motor set of nerves, and even portions of the heart, when detached, will remain impressionable and give signs of irritability. Mr. Erichsen has shown that the heart loses its irritability after the greater portion of the blood sent to its muscular fibres is cut off, by ligature of the coronary arteries. It would appear from this, that there may be some connection between the movements of the heart and the performance of the function of nutrition continually at work in its intimate structure. The exigency for the supply of oxygen existing in the tissues, and the organic changes that take place during assimilation, with appropriation of oxygen, and disassimilation, with elimination of carbonic acid, may create, by reflex action, a necessity for movement, a "*besoin d'agir*," analogous to the "*besoin de respirer*" which takes possession of the muscular apparatus of respiration through the same nervous agency. If the systole and diastole of the heart be considered to depend, in part, on the oxygen demanded for its nutrition, and, in part, on the presence of the circulating

fluid in its cavities, these influences must still be regarded as originally emanating from the agency of the diversified nervous ganglia and branches by which its substance is supplied, and the reflex action resulting from the connection of these with the medulla spinalis and medulla oblongata. An organ so highly endowed as the heart must be profoundly impressed and perturbated by the shock of a severe injury, and its action will be changed and modified by the intensity of the injury, the nature of the organ injured, and the seat or location of the lesion. The character of the changes that take place in the cardiac movements may range from the fluttering, feeble, and rapid action that one observes after sudden and trivial succussions to the general system, to the slow and labored impulsion following upon severe lesion to the brain from fracture of the cranium, with depression of bone and effusion of blood. It has been proposed to measure the action or beatings of the heart in disease by the use of the cardiometer, but such instruments, ingenious as they appear to be, in practical surgery are more curious than applicable in calculating the symptoms that occur after external injuries. The frequency, regularity, and force of the action of the heart afford, to a certain extent, correct information concerning the general condition of the system, making allowance for correlative circumstances, such as age, sex, climate, peculiarities, muscular activity, etc., and in disease the indications of treatment are often deduced from the character of the impressions imparted to the touch and to the ear.

The Pulse.—The arteries possess the property of elasticity, and at each ventricular systole respond by an almost synchronous expansion.* Being sometimes superficial, readily recognized, and easy of access, they are selected for convenience to study the nature of the pulse, in preference to the more tedious and inconvenient exploration of the heart. The blood-vessels, like the heart, are supplied by their proper nerves, derived principally from the sympathetic, the filaments of which are distributed to the arteries as far as their ultimate ramifications. A set of nerves forming a net-work of filaments among the muscular coats of the arteries, and having the functions or

* The progressive retardation of the pulse as we recede from the heart, calculating the difference between the ventricular systole and the pulsation of the artery in the foot, has been estimated at one-seventh of a second.

capability of regulating their calibre and the quantity of blood sent to the several tissues, were first noticed by M. Brown-Séquard, who named them vaso-motor nerves, on account of their peculiar characteristics. These nerves regulate the local circulations, also the circulation in the secretory glands, which require at times an additional supply of blood when under the influence of their special stimuli; and it is probable that a similar nervous agency is exerted over the muscles, the brain, and other parts of the system which are liable to be brought suddenly into action. The phenomena of blushing, and the leaden pallor that spreads over the countenance from mental emotions, are mentioned as common examples occurring from this source of nervous action.

The extensive anastomoses between the sympathetic nerve and the ordinary nerves of sensation and motion render it difficult to determine exactly the origin of the vaso-motor filaments; but the physiological experiments recorded up to the present time seem to prove that the vaso-motor nerves derive their source exclusively from the cerebro-spinal system. The arteries, from their elasticity and contractility, and from the abundant nervous distribution with which they are supplied, possess inherent qualities that are independent of the mechanical impulse imparted by the ventricular action of the heart, and by which the successive waves of blood are injected into the arterial system. The effect on the heart and arteries of a severe shock will be understood when the physical conditions are considered upon which the character and quality of the pulse essentially depend. The proper amount of the nervous power of the heart, the normal condition of the mechanism which that power directs, so as to propel the blood into the arteries, the quantity and quality of the blood in the circulatory system, the healthy character of the arterial tunics, and of their vaso-motor supply, are the necessary conditions for the natural pulse. When one or more of these conditions become abnormal, the several morbid varieties of the pulse that are observed in practice are met with. In severe lesions, as from a crushed limb where asthenic symptoms are present, the nervous power of the heart becomes diminished, the blood is not propelled into the vessels, and the pulse becomes small and feeble. So also in anæmia, where the loss of

blood has been exhaustive, the pulse diminishes at times so as to be scarcely perceptible at the wrist, on account of the absence of the necessary supply of blood to the heart. In cases of apnœa, the pulse will be frequent, feeble, and weak from the loss of nervous power, and from stagnation of blood in the capillaries of the lungs and in the right cavities of the heart. In pure coma, as happens in compression of the brain from fracture of the skull or from laceration of cerebral vessels, the pulse at first will be slow and full, but the nervous power of the heart soon becomes diminished, and its action ultimately becomes rapid and feeble. Where the action of the heart and pulse is rapid and bounding but easily compressible, and afterward becoming feeble, irregular, and accelerated, embracing, with other symptoms, the condition described by Mr. Travers as characteristic of "prostration with excitement," the nervous power of the heart is failing. There is a condition of the heart, already alluded to, characterized by a sudden commotion of the organ, where the beatings are sensibly felt by the patient, and the pulse runs up to 160 in the minute, or even so rapidly as to be beyond counting, and continues at this rate from a few seconds to a minute or more, and then suddenly resumes its ordinary rhythm. This form of cardiac perturbation, called "folie du cœur," sometimes met with in collapse, is indicative of nervous exhaustion of the nerves of the heart, more particularly of the pneumogastric, which presides over the rhythm and muscular tonicity of the heart. When, with other unfavorable symptoms, the pulse becomes continuously rapid, running up to 160 or upward, and at the same time is irregular and feeble, the nervous exhaustion is well-nigh completed, and there is probability of dissolution.

Some years since the sphygmograph was introduced first by Vierordt, and afterward, in an improved form, by Maret, for the purpose of measuring the amount of dilatation and movements of the arteries, and for indicating more exactly the character and quality of the pulse in disease. But the pulse is subject to numerous anomalous variations, even in health, and cannot be altogether relied upon as the absolute criterion of the pathological condition of the system. A case came under my observation lately, where the pulse beat quite normally in an adult who had received a pistol-shot a

few hours before, the bullet lodging in the anterior lobe of the brain; and it is well known that in some instances of insidious shock, and in the earlier stages of purulent infection, the pulse will sometimes beat without abnormal variation. Some of the older physicians, among them Heberden, considered the pulse by no means an adequate guide in forming a correct judgment of disease, and that, if exclusively relied on, it would sometimes lead to erroneous conclusions. The instrument of Maret, ingenious as it is, and useful in experimental physiology, cannot be turned to much practical account in determining the nature and import of the pulse in complicated affections, where, as yet, more reliance must be placed upon observation of the correlative facts, and the knowledge which is acquired by experience through the medium of the touch. The pulse, however, notwithstanding its shifting and anomalous phases, and the various conditions of the vital powers and of the idiosyncrasies by which the circulation may be modified, must be regarded as of great importance in clinical practice. Ranging, in the successive stages of life, from the new-born infant with the pulse of 130 or 140 beats in the minute, to the adult male with 70 or 75, it has been characterized, in its relation to *time*, as frequent or rare, quick or slow; in the relation of *force*, as strong or weak, hard or soft, full, small, or wiry, free or compressed; in the third relation of *equality*, as the irregular pulse, with respect both to time and force, with the varieties of each, as the intermitting, the rebounding, the fluctuating, or wavering pulse. The compressible and incompressible pulse may be added, and with those just designated may be regarded as the most distinct and unequivocal prognostic and diagnostic signs that are afforded through the instrumentality of the pulse.

Depressed Temperature of Surface.—One of the most prominent symptoms of collapse is a depressed condition of the temperature of the body; in fact, a cold, clammy surface is one of its characteristic features. The explanation of this manifestation is best reached by considering the nature and sources of the normal supply of animal heat to the system. The term calorification was used by Bichat to express the evolution of caloric that takes place in the animal economy during life, and was described by him as a function subordinate to the fulfillment of the performance of all the other

functions. The vagueness here is in the nomenclature, in making use of the word function, instead of distinctly defining the liberation of heat as a result, and not as a special act in the economy, such as digestion or respiration. Oxygen is dissolved as oxygen in arterial blood, and disappears in part or entirely in the capillary circulation. Carbonic acid is taken up by the venous circulation, and is held in solution, or in feeble combination with the alkalies, as carbonates and bicarbonates, to be expelled from the lungs in expiration, when freed by the action of pneumic acid. It is also ascertained that the tissues themselves have the property of appropriating oxygen, and of eliminating carbonic acid along with the other products of their physiological decay.

Admitting these facts, the theory of Bichat, referring the development of animal heat to the general result of all acts of assimilating composition and of disassimilating decomposition which take place in the entire organism, is preferable to the more limited doctrine of Lavoisier, that ascribed the evolution of animal caloric solely to chemical action taking place in the pulmonic system. The theory of latent heat, originating with Black of Edinburgh, may enter into the explanation of the evolution of animal heat. During the process of nutrition, while the operations of assimilation and of disassimilation are going on, the equilibrium of the atoms in the alimentary compound present in the blood becomes disturbed and changed, and the elements arrange themselves into new forms, one set of atoms becoming utilized for repair of the tissues, while another is eliminated from the system in the form of excrementitious material. It is quite probable that while this molecular interchange or metamorphosis is taking place, heat is necessarily produced and liberated, as occurs in some kinds of fermentation, and also in the transformation of certain oxides, as the white oxide of calcium, which has a great affinity for carbonic acid and for water, with which it rapidly combines to form a hydrate, while at the same time there is a great evolution of caloric. Among the many hypotheses given out at different times, the theories of Lavoisier and of Bichat alone merit consideration at the present day, but they still leave certain details unexplained. As the nervous system maintains over nutrition a certain power, so in the pro-

duction of caloric the sympathetic and cerebro-spinal systems exercise a regulating influence. Section of the sympathetic on the side of the neck is followed by increased vascularity and heat in the region where the branches are distributed, and from this it might be inferred that injury to this portion of the nervous apparatus could not have any effect in the generation of animal heat; but the vaso-motors of the nervous system, "*les dilatateurs cerebro-rachidiens et les constricteurs sympathiques*," so called by Bernard, exercise an important influence. Besides, in shock produced by grave lesions followed by collapse, the nervous battery, composed of the ganglia of the great nervous centres, is greatly perturbed; nutrition is generally interfered with, and the production of animal heat, its invariable coincident, is diminished or altogether arrested. On account of the inability of the heart, from loss of nervous power, to propel the blood through the system, the circulation in the smaller arteries and capillaries also becomes feeble, or is altogether suspended, and this part of the process of calorification is impeded, or ceases to be performed. From these several causes the temperature of the surface necessarily becomes lowered, and assumes in some instances the coldness of death. In cases of shock the ruddy appearance of the healthy countenance is changed almost immediately into a dull, leaden pallor, and the vermilion lips assume a pale, livid hue. Some of the causes that operate in producing the change of temperature of the surface, are also the sources of the altered appearance of the face. A deadly pallor of the countenance is often produced by the action of the vaso-motor nerves in vivid mental emotion, resulting from the contracted state of the calibre of the arterioles and capillaries that ensues, while the amount of blood distributed to the surface is lessened by the enfeebled action of the heart, and leucocytes take the place of the red globules of the blood in the diminished amount of circulating fluid that reaches the vessels. The cold, clammy moisture that is generally present in shock followed by collapse cannot be called a secretion, but is, no doubt, a transudation or exosmose of some of the liquid and saline constituents of the blood, which escape through the cutaneous tissues from the relaxed capillaries, and become cold, in keeping with the low temperature of the surface.

Disturbed Respiration.—In cases of shock, respiration, like the circulation, is disturbed from similar causes, that is, from the failure of the nervous supply emanating from the nervous centres to be transmitted along the proper nerves to the pulmonic apparatus. The pneumogastric and sympathetic nerves play an important part here as in the action of the heart. The act of respiration, like that of the circulation, partakes, in a great degree, of a mechanical character, the latter simulating a hydraulic, while the former is of the nature of a pneumatic, machine. In both instances, however, the organs themselves are animated from nearly the same sources. The pneumogastric and sympathetic nerves supply the organic and vivifying influence to the lungs, and also, in connection with the alteration that takes place in the blood, preside over the chemical interchange of the gases, while the general sensory nerves transmit to the medulla oblongata the "respiratory sense," the *besoin de respirer*, or the sensory impression of want on the part of the system which induces, by reflex action, the respiratory movements. As artificial respiration becomes an important element in the treatment of severe collapse, its mechanism may here be alluded to.

The muscles of the rima glottidis, which opens and closes for the entrance and transmission of air to and from the lungs, are animated by the inferior laryngeal branches of the pneumogastric nerves; but another set of nerves, which take their origin from the medulla spinalis, supply the numerous muscles which effect expansion and contraction of the walls of the thorax during inspiration and expiration. Of these the phrenic, or internal respiratory, the branches of which are mainly distributed to the diaphragm, and the posterior thoracic, or external respiratory of Charles Bell, which arises from the fifth and sixth cervical close to the spine, and supplies the serratus magnus, are the most important. The other muscles connected with the mechanism of respiration are, in general, animated by nerves from the medulla spinalis. It may be generally stated that inspiration is effected by descent of the diaphragm and elevation of the ribs, while expiration is produced by the rising of the diaphragm and descent of the ribs.

The external intercostal muscles, eleven in number, take their origin from the lower border of each rib, and are attached to the upper border of

the rib below; the fibres of each have an oblique direction from above downward and forward. The internal intercostals are attached to the inner borders of the ribs, and take a direction from above downward and backward, nearly at right angles to the fibres of the external intercostals. Several other muscles are attached to the thorax and spine, thorax and head, to the scapula, and upper part of the humerus. These, when in action, are capable of elevating the entire chest or the ribs; and when their insertions at the thorax become movable points, they will act as muscles of inspiration. Some of these muscles, such as the diaphragm, the scalenus anticus, scalenus medius, scalenus posticus, the external intercostals, the sternal portion of the internal intercostals, and the levatores costarum, are called into action during ordinary inspiration. Some, such as the serratus posticus superior and sterno mastoid, act when respiration is labored, and are called ordinary auxiliaries; while other muscles, which generally have a different function, but which are brought into action when respiration is exceedingly difficult, such as the levator anguli scapulæ, the superior portion of the trapezius, the pectoralis minor, a portion of the pectoralis major, and the serratus magnus, are called extraordinary auxiliaries.

The general elasticity of the pulmonary tissues and of the cartilaginous and osseous walls of the thorax, especially in the young, renders the act of expiration more passive in its character than that of inspiration. When the muscles of inspiration, or those which increase the capacity of the chest, cease their action, the natural resiliency of the costal cartilages and the tonicity of the muscles which have been put in action will reduce the chest to its passive dimensions. Certain muscles, too, draw the ribs downward which in ordinary respiration do not elevate the ribs; and many chest movements, such as are made by the tenor or the public orator in singing or speaking, require prolonged and complicated efforts of expiration, which also bring numerous muscles into play. The muscles of ordinary expirations, or those muscles which diminish the transverse and antero-posterior diameters of the thorax by depressing the ribs and sternum, are the internal intercostals at their osseous attachments, the infracostals, and the triangularis sterni. These muscles receive their nerves from the thoracic spinal nerves. The

auxiliary expiratory muscles that diminish the vertical diameter by crowding up the abdominal viscera, so as to press upward the diaphragm, are the obliquus externus, the obliquus internus, the transversalis, and the sacro-lumbalis. Other muscles are sometimes brought into action by forced expiration, as the serratus posticus inferior, the inferior fibres of the serratus magnus, and the inferior portion of the trapezius. These may be called auxiliary muscles, and, like the muscles of ordinary expiration, are animated by the mixed spinal nerves from the dorsal and abdominal sections of the medulla spinalis and sympathetic.

In injuries where the function of respiration is primarily attacked, or in lesion of the medulla spinalis from fracture or dislocation of the spinal column above the origin of the phrenic nerve, we have examples of extinction of life from apnœa, or, according to Bichat, of death beginning at the lungs. From this brief *résumé* given of the mechanism of respiration, we find that the nerves which animate the different portions of the pulmonic apparatus are derived from the pneumogastric, the cervical, dorsal, and lumbar spinal nerves, and from the sympathetic, after sending its communicating branches to the other nerves. The respiratory apparatus, from the importance of its functions, is easily disturbed when deprived of the vivifying and balancing influence maintained by the nervous force transmitted along these nerves in the normal condition of the great nervous centres, and in cases of severe injury speedily manifests symptoms of perturbation, according to the locality, and in proportion to the extent or impression of the lesion.

Respiration, since the experiments of Volkmann made known in 1841, is really not supposed to depend on the lungs for its seat, but the sensation of want of air is regarded as being dependent on the deficiency of oxygen in the tissues, and on the impression thus produced and conveyed by the nerves of general sensibility to the medulla oblongata, to be thence reflected upon the pulmonic apparatus through the medium of its proper nerves. Allowing this supposition to be correct—that the respiratory sense lies in the general system, and not in the lungs alone—and granting that respiration is the process by which all the tissues and organs receive and appropriate oxygen

from the blood, yet the respiratory apparatus, that is, the thoracic walls, the muscles of respiration, the lungs, and the nerves by which these structures are vivified, must be reckoned as the principal mechanism by which the introduction of oxygen into the blood and the exhalation of carbonic acid are mainly effected. The process of respiration may be interfered with by direct injury to the brain, or to the medulla spinalis above the origin of the phrenic nerve, and severe and sudden lesion of the medulla oblongata is followed by immediate death. More frequently the effect of a severe injury, as the crushing of a limb by the passage of the wheel of a railroad car, is transmitted to the nervous centres, and thence radiated upon the nerves of the pneumatic apparatus. In this case the thoracic wall and lungs cease to play, the supply of oxygen is cut off from the blood, carbonic acid is not eliminated, the contents of the systemic capillaries become stagnant, the various tissues and organs do not receive or appropriate oxygen, and the patient is destroyed by apnœa. In such cases the mouth is open, and there is a gasping for air, as a fish, when landed on the beach, moves and expands the gills in a dumb effort to obtain the oxygen of its native element.

The average number of respirations in the adult may be estimated at from sixteen to twenty in the minute, but these are subjected, like the impulsions of the circulation, to the physiological influences of age, sex, posture, sleep, muscular effort, etc. As in relation to the pulsations of the heart, age has a marked influence on the respiratory act, ranging, during the successive periods of life, from 44 respirations per minute in the infant, soon after birth, to the average standard of 18 respiratory acts in the adult aged from thirty to sixty years. Approximately it may be considered that at the age of five years the number of respirations per minute is 26; from fifteen to twenty, 20; from twenty to twenty-five, 19; at thirty, 16; and from thirty to sixty, 18.

The ratio of the respiratory movements to those of the heart in health has been computed to be in the proportion of four pulsations of the heart to one of respiration. This is, in the majority of instances, constant in health, and also in disease, where the pulse is accelerated, except where the pulmonary tissue is affected or altered in structure. In some cases of external

injury, however, and often in approaching dissolution, this relative action of the circulation and of respiration does not hold good, the pulse beating very rapidly, while the respiratory acts are slow. These figures may serve as approximative data in relation to the abnormal respiratory movements as observed in cases of shock and collapse.

Restlessness, Jactitation.—Restlessness and jactitation, often met with as symptoms in collapse following shock, are referable to the same cause, viz., a change in the character of the blood, producing a morbid impression upon a portion or upon the whole of the nervous centres, which is reflected back along the efferent nerves upon the locomotor organs. In restlessness following shock there is a morbid and, to a certain extent, an uncontrollable feeling or necessity to change from place to place, and in jactitation the body is tossed about from one position to another, even when there remains no longer any consciousness. It has already been related that the sensation of want of air—the "*besoin de respirer*"—felt on the part of the system, which induces the respiratory movement, is believed to be dependent on a deficiency of oxygen in the tissues, producing an impression which is conveyed to the medulla oblongata by the nerves of general sensibility. This explanation, which, in some cases, may be applicable to the occurrence of restlessness, jactitation, and muscular commotion, will probably supersede the theories of Marshall Hall, of Reid, and of the elder Bérard, and to it can be referred, with much reason, the rationale of many phenomena apparently automatic which follow upon injuries.

In profuse hemorrhages, besides the change in its composition, the circulating mass becomes deficient in quantity, and the diminished supply of oxygen thus resulting to the system affording new abnormal impressions, may thus promote morbid reflex manifestations upon the muscular system. Moreover, restlessness and jactitation may also result from direct irritation of certain portions of the brain, as of the tubercula quadragemina, received during severe injury, as in concussion, and thence reflected upon the general locomotor apparatus.

Convulsions.—Convulsions are a still more intense manifestation of muscular commotion occurring frequently after shock. They are ushered in by

sudden and violent contraction of the muscles, sufficiently powerful to produce contortions of the face, and an irregular movement of the body and extremities, with tremors of greater or less violence, in many instances frequently repeated, with intervals of calm and relaxation. The muscles are the organs apparently affected, but the convulsive act is one of abnormal innervation, showing itself by signs of morbid reflex action. Convulsions often occur without any inflammation or appreciable organic change in the solid tissues, but are dependent on irregularity of the circulation, the condition of the blood, or the accumulation of cerebral serosity. In uræmia, in albuminuria from pregnancy, in Bright's disease, and in conditions of the system associated with apnœa, the blood is known to be vitiated by excrementitious materials which have not been eliminated from the system, and to be from this cause the source of convulsions. The morbid impression on the nervous centres, originating from contaminated blood, and kept up for a considerable time upon portions of the encephalon, may produce a condition of local irritation upon the cerebral structure which may remain, and prolong the symptoms after the subsidence of the original cause. The experiments of Flourens, of Longet, and of Brown-Séquard prove that lesion inflicted deeply upon the tubercula quadragemina produces convulsive movements from direct irritation of the cerebral structure, examples of which are met with in concussion of the brain, in the irritation produced by depression of bone from fracture of the cranium, and in the effusion of blood into the substance or on the surface of the brain, the disturbance being transmitted in such accidents to certain parts of the encephalon.

Thus we see that after shock following severe injuries or hemorrhages, the convulsive act may be produced by the diminished quantity or the altered condition of the blood abnormally impressing the nervous centres, or the irritation may be from the seat of local injury within the cranium to portions of the brain, to the medulla oblongata or medulla spinalis, and thence reflected upon the muscular system, or, again, the focus of convulsion may be toward the general periphery, as in the crushed limb, and the morbid impression be carried up from the seat of injury to the medulla spinalis, and then reflected upon the muscular apparatus.

Arrest of the Secretions.—The secretory organs and glands, such as the liver, the kidneys, the follicles of the skin, and mucous membrane, are presided over by the nervous apparatus, and cease to exercise their functions in severe cases of collapse. The excessive thirst present, when sensibility remains, can be accounted for by the interrupted secretion of the membrane of the mouth and fauces, and possibly by the sensation of a want of fluid, arising from a deficient supply of oxygen in the blood, causing an automatic craving for drink through reflex action. As already stated, the transudation of moisture, producing what is called the cold, clammy sweat of collapse, may be considered as a kind of exosmose resulting from the general relaxation consequent upon faulty innervation, and not as a secretion.

Condition of the Pupil.—The iris, with its pupil, is placed before the retina as a sentinel of protection to guard it against injury, and to modify the admission and the intensity of the rays of light before they impinge upon it. The nervous mechanism by which the actions of the pupil are carried on is very complicated, and in health its susceptibility to impressions from without and within the cranium is extremely delicate. In disease it may be morbidly sensitive, or its movements may be abnormally sluggish and tardy, or it may be absolutely immovable, remaining so either in a state of contraction or of dilatation.

In collapse, the pupils are contracted and immovable in many cases where concussion simply has taken place. They are, at times, dilated, and not susceptible to the influence of light, as in injuries of the head where concussion is accompanied by compression of the brain. It may be inferred from this that in external injuries dilatation of the pupil accompanied by immobility is indicative of a lesion more profound than when the iris is in a state of contraction, or, in other words, that the impression of injury on the system has been radiated more extensively and penetrated more deeply. In the administration of anæsthetics, it is found that the organic nerves are the last to be affected, the cerebro-spinal system being the first to respond to their influence. The nervous distribution to the iris is quite complex, and it is only by the consideration of the anatomical mechanism that the various conditions which it assumes in accident and disease can be

explained. The lenticular ganglion is composed of a small centre of gray matter situated between the inferior oblique muscle of the eye and the optic nerve, and receives its sympathetic influence from the superior cervical ganglion by way of the cavernous plexus, which, after giving off small branches to the mucous membrane of the sphenoidal sinus, to the dura mater of the basilar process, to the pituitary body, to the third, fourth, and sixth pair of cranial nerves, and to the ganglion of Gasser, sends a branch, relatively of considerable size, to the ophthalmic ganglion. Thus formed, it receives a branch from the motor oculi, or third pair, which supplies its motor root, while the nasal branch of the fifth pair, carrying with it also the sympathetic connection, supplies the sensitive root, in this respect resembling the ganglions on the spinal nerves. From the anterior part of the ganglion thus formed, the ciliary nerves take their origin, and after traversing the sclerotic, pass between that membrane and the choroid to reach the iris, where they are distributed. The experiments of Budge and Waller go to prove that the filaments of the sympathetic which preside over dilatation of the pupil make their connection with the spinal cord between the sixth cervical and the second thoracic nerves, and it is at this point that the inferior cilio-spinal centre is said to be situated. There is also described a superior cilio-spinal centre, possessing the same influence over the dilatation of the pupil, in communication with the superior cervical ganglion, and located higher up in the cord, near the origin of the sublingual nerve. The tubercula quadragemina and optic thalami are also, no doubt, nervous centres through which the movements of the iris act, and contribute to the protection of the retina and the enlargement and perfection of the field of vision.

Two distinct nerve centres seem to be in correlation with the two sets of nerves which regulate or preside over the movements of the iris. One of these centres, the tubercula quadragemina and optic thalami, through the optic nerve and the third pair, presides over the reflex contractions of the iris; and the other centre, localized in the spinal cord, influences dilatation of the pupil through the branches of the grand sympathetic. From these data we perceive that this delicate structure is in communion with all the

organs and tissues of the body that are supplied by nerves, and that, although the analysis is complicated, we can thus account for its activity and rapid sympathy with physiological or pathological impressions, and, while sensibility remains, for the dilatation or contraction of the pupil in accordance with the greater or less intensity of the impressions made upon the cilio-spinal or cilio-cerebral nervous centres. Permanent pressure upon the retina may occur from an engorged or congested condition of the choroid; or it may be amaurotic, and then the pupil is dilated from disease within the globe of the eye itself; but when the pupil is dilated following upon a severe injury of the head, and the globe of the eye is healthy, there is reason to believe that there is lesion of or pressure upon the optic nerve and the tractus opticus, or upon the cilio-ganglionic masses in which they terminate or with which they are connected. In very severe concussion which may be recovered from, the pupils may be dilated, but in such cases the molecular arrangement of the ganglionic centres is rudely shaken and jarred. As a general rule, however, the abnormal pupil indicates serious injury, or compression of the optic nerve and the ciliary nervous centres. Contraction of the pupil, often met with in medical diseases, is frequently present in concussion when the brain is not fatally injured, and indicates a pathological condition of the cerebral structure, but not generally the total obliteration of its function. Cases of severe injury to the brain are sometimes met with where there is contraction of one pupil and dilatation of the other, and here we should expect to find the pupil dilated on the side opposite to that on which there existed the most serious injury to the brain.

Varieties of Shock and Collapse.—The organs and tissues of the body are constructed and supplied so differently with nervous influence that the impressions made on the system from injuries of such severity as to produce shock must, as a physiological consequence, be accompanied by diversified phenomena. Besides the variety of locality, other circumstances are presented which will often change the character of the symptoms in serious accidents. Thus, for example, a person may be wounded by a pistol bullet passing through the temple and lodging in the anterior lobe of the brain.

He may be knocked down by the concussion, but will get up and walk for a distance of several rods to his home, and lie down upon a lounge, manifesting but few signs of so grave an injury, while another person having a limb crushed from the passage of a railroad car will be affected with symptoms of shock and collapse so severely as to threaten dissolution. From the vast net-work and numerous ramifications of the different divisions of the nervous system, and from the decussations and commissures uniting the several lateral ganglionic masses of the cerebro-spinal system, as well as from the varied functions and unequal sensibilities of the component structures of the body, it might be expected that impressions resulting from external injury and followed by shock would not always be attended with symptoms of equal severity or by phenomena of a similar character. The effect of a shock may be limited or localized, or the force falling upon more organs than one, its intensity will be distributed in different directions, and the symptoms consequently modified. If the influence of the shock has been directly imparted to the encephalon, as takes place in concussion of the brain, cerebral perturbation will be first developed, while in severe lesions of the extremities the organs of circulation and respiration, and the splanchnic organs, will manifest signs of derangement as the primary effects. The amount of concussion, or the intensity of the force applied, as well as the situation and nature of the organs affected or implicated, must be taken into account in estimating the possible effects in particular cases of shock. Where the impinging force has been comparatively slight, the more trivial symptoms will be present, as coldness of the surface with clammy sweat, paleness, and a sense of depression, accompanied by increased frequency of respiration, a rapid pulse, tremors, and anxiety. Where the shock has been more severe, the signs of collapse are more marked; sensibility and the motor power are lessened; the intelligence wavers and shows signs of incoherency; the pulse is feeble, small, tremulous, and sometimes intermitting; the respiration becomes irregular and sighing; the countenance assumes a leaden and pallid hue; there are rigors, with a cold surface and clammy sweat, vomiting, and sometimes convulsions. A train of symptoms still more serious, indicating what may be called the third grade of collapse,

is recognized by symptoms of a very grave character. The manifestations met with in the second form just enumerated are more aggravated, and to them are added delirium, coma, insensibility, irregular respiration at long intervals and faintly perceptible, the pulse so feeble as scarcely to be felt at the wrist, involuntary discharges at times, with cold clammy moisture and deadly coldness of the surface. In the fourth form of shock the general vitality and functions of the body are overwhelmed, the patient is speedily plunged into entire insensibility, the intelligence is annihilated, the pulse and action of the heart become imperceptible, the respiration is gasping, occurring at long intervals, the surface cold and clammy, and, with half-closed glassy eyes and fallen jaw, the patient dies comatose or in convulsions. This succession of morbid phenomena is the typical or ordinary sequence of injuries followed by collapse. Other conditions are met with of a more anomalous character occurring after severe lesions, different in their progress and mode of termination, and if not understood, are apt to lead to erroneous prognosis and misdirected treatment.

Latent Shock.—Two conditions of the system resulting from injuries are met with where the term *latent* shock may appropriately be applied. In one case, the impression made upon the vitality is much greater than is indicated by the amount of the external manifestations of lesion, the source of the gravity of the symptoms being occult and obscure, or altogether hidden. In the other, the effects of the injury are developed to a much less degree than the great extent of the lesion would lead the observer to anticipate, the nervous system being rendered too torpid and too prostrated to appreciate or take cognizance of the real gravity of the accident. In both instances the effect does not appear to be commensurate or in correlation with the cause. One variety of *latent* shock is characterized by the absence of any mark of external violence, as in cases of sudden death or severe collapse from sharp blows upon the epigastrium, from the concussion, comminution, or laceration among the deep tissues or internal organs produced by wind or spent ball, or from similar injuries inflicted by the general concussion and contusion that take place from destructive and fatal railroad accidents. Persons receiving such injuries, although pale, will have the circulation and

the respiration scarcely affected. They have the power of locomotion for a brief period, and will get up and walk. There will be no expression of pain, but the countenance will be wild and staring, as if panic-stricken. Suddenly signs of great prostration are manifest, the powers of life become exhausted, and the patient sinks gradually into coma and death. In cases of this character there is no time for the development of inflammation or of marks of external injury, on account of the sudden annihilation of the vitality. The phenomena of such accidents are explained by the occurrence of internal lesion and disorganization from mechanical contact of some hard material, such as a cannon-ball, or from laceration of the deep tissues, as happens sometimes from severe concussion, or from abrupt devitalization of the blood, as in case of death by lightning. Numerous theories have been suggested in explanation of cases of sudden death taking place without external evidences of local or general injury. The following interpretation, given by Baron Larrey, is the most lucid and correct, and although referring mainly to what is called wind or spent ball, embraces the general principles applicable to this class of accidents:

"A cannon-ball is propelled at first with a rectilinear movement; and if, during this part of its course, it strikes against any part of the human body, it carries it away; but the ball, after having traversed a certain distance, undergoes some change of motion in consequence of the resistance of the atmosphere and the attraction of the earth, and turns on its own axis, in addition to the direct impulse received from the explosion of the powder. If it should strike any part of the body when the velocity with which the ball is passing is greatly diminished, it does not carry it away, as in the preceding case, but, in consequence of its curvilinear or rolling motion, it turns round the part in the same manner as a wheel passes over a limb, instead of forcing a passage through it. The soft elastic parts, such as the skin and cellular membrane, yield, while the bones, muscles, tendons, arteries, etc., offering a greater degree of resistance, are either bruised or ruptured. If the ball should strike one of the cavities of the body, the viscera suffer in like manner."

A good example of latent shock that came lately under my observation

was that of a boy about fifteen years of age, who was sleeping on a mattress on the floor of a room where the plastering of the ceiling happened to be loose. A club of college boys had the apartment above, and were engaged one evening in rollicking games, dancing, jumping, etc., in the course of which a large portion of the ceiling fell, striking the boy on the abdomen while asleep. He was awakened by the blow, and was seized with great pain, coldness of the surface, quick feeble pulse, hurried respiration, and the usual concomitants of severe collapse. These symptoms, added to others of a still graver character, continued until death closed the scene, about five hours after the accident. Externally there was no sign or mark of injury, but the *post-mortem* revealed a lacerated rupture of the small intestine of considerable extent, through which a large lumbricus had crept, and was found in the cavity of the peritoneum. There was no sign of peritoneal inflammation.

The case of William Poole, the pugilist, who received a gunshot wound in the heart, furnished an instance of the fallacious calm that takes place in severe injuries between the time of the receipt of the shock and its termination in death. Poole received his wounds during a deliberate onslaught made on him by some five or six persons armed with Colt's revolvers. The first ball took effect on his right thigh, and brought him to the ground. While thus prostrate, another assailant placed the muzzle of a pistol close to his chest, and discharged its contents. He immediately jumped up, and reeling toward a door, rested, as if stunned, against it for support during some minutes. He then fell, exclaiming that he was dying, and remained senseless, cold, almost pulseless, and apparently moribund for about four hours. From this condition he rallied, and became so free from the usual symptoms of severe injury, that his medical adviser considered that the ball had really not penetrated into the thoracic cavity, and my opinion was sought to corroborate or dispel this favorable view of the case.

I found him sitting up in bed, his back resting on pillows as a support, apparently at ease, and conversing with numerous acquaintances who had come to visit him. His countenance exhibited no expression of anxiety, and he answered placidly and without effort the questions I put to him. His

pulse was eighty, the respiration easy, the surface of the body normal in temperature and moist. The stethoscope revealed the existence of no difficulty in the respiratory passages, and the normal tick-tack of the heart beat with healthy precision. There were no signs of inflammation or of effusion into the pericardium. These favorable symptoms continued until the eighth day after the accident, when he received, against positive orders, the visits of more than a hundred people, with whom he conversed. His own statement was that he felt quite well. The next morning, about eight o'clock, he was in a high state of irritability; pulse one hundred and twenty; skin hot and dry; complained of pain generally; respiration troubled and more frequent. An aperient was ordered, by which the symptoms were much alleviated. On the tenth day the pulse was one hundred; countenance anxious; the adnata tinged yellow; complained of debility, but said he had no pain about the heart; signs of effusion. He passed a restless night, notwithstanding the administration of an anodyne; pulse one hundred and twenty; countenance more anxious; respiration much troubled; inability to remain in the recumbent posture; symptoms gradually becoming more grave. At two o'clock the next morning the patient was rapidly sinking; pulse almost imperceptible, and with difficulty counted; respiration short, frequent, and difficult; extremities cold; countenance pallid and hippocratic. From this time he continued to sink, and expired, without a struggle, at 5 A.M.

This case will be recorded in full hereafter.

The case of James Fisk, Jun., the Erie Railroad manager, presented also an instance where the injury was exceedingly severe, and yet the distressing symptoms following the shock soon subsided. Fisk was shot on the stairs of the Grand Central Hotel, about 4 P.M., with a revolver. The ball entered the abdomen on the left side, about five inches above the level of the umbilicus, and two inches to the right of the median line, passing obliquely downward and to the left through the abdominal wall, and traversing the small and large intestines and mesentery, pierced the tissues below Poupart's ligament, and lodged in the groin on the opposite side, near the insertion of the psoas magnus. Upon receipt of the injury he fell, and was taken to a room in the hotel, the symptoms of collapse following imme-

diately upon the shock. He complained of great pain in the abdomen, the surface was cold, clammy, and moist, pulse rapid and feeble, respiration frequent, his features pinched, and he was more or less stupid in answering questions. These symptoms soon passed off, and I saw him at 11 P.M., seven hours after he had been shot. In the mean time he had been seen by the hotel physician, through whom several others had been called in. A passive reaction was being established, but morphine subcutaneously and internally had been administered in large quantities. I found him with few signs of collapse. His countenance was somewhat pale, the pulse was seventy-two, the respiration rather slow, intelligence dull but correct, and when questioned he stated that he had very little pain. I had to return to the country immediately, and left suggesting caution in the farther administration of opium. The morphine, however, was continued in unusual quantities, and Fisk died apoplectic at 5 A.M., about thirteen hours after the receipt of the injury. Fisk's wound was severe, and might have proved mortal, yet there was no abdominal effusion of any kind except a small portion of blood to the extent of a silver half dollar in form of clot. There was no evidence of peritoneal or other inflammation, and the orifices made by the bullet were closed, and apparently would have become united. There is no doubt that his death was accelerated by the excess of morphine that was administered.

The two following cases are examples of fatal injury where the effects of shock were latent, and entirely disproportionate to the gravity of the lesion:

CASE I.—Ferdinand Holland, a native of France, æt. 62, while driving on the road in the country was overturned with his top wagon, August 5, 1865, and received an injury of the head. Dr. Freeman, of West Farms, saw him within a quarter of an hour after the accident, and found him sitting on the curb-stone by the side of the road. He acted in a very obstinate manner, and would allow nothing to be done for him, and walked over half a mile to the house of a friend. He conversed intelligently for two hours, the pulse and temperature of the body remaining nearly natural, and in other respects he was free from the ordinary signs of collapse. In three hours he became insensible, and began to sink rapidly. A dispatch was now sent to New

York for me to meet Dr. Freeman in consultation, and I reached the case seven hours after the occurrence of the accident. He had received a fracture of the cranium, with depression of bone on the anterior part of the right temporal region, but as the symptoms of approaching dissolution were apparent, I advised against an operation. He died at half past three A.M., eight hours after the receipt of the injury. At the *post-mortem* examination there was found a fracture of the lateral portion of the frontal bone, a portion of which, nearly an inch in diameter, was driven into the substance of the anterior lobe of the brain to the depth of two inches.

Case II.—On September 13, 1873, I was called in consultation, also by Dr. Freeman, of West Farms, to see E. Miller, aged 54 years, who had shot himself with a pistol about seven o'clock on the morning of the same day. The ball entered the right temple, making an aperture in the cranium through which some blood and cerebral substance oozed out. He had fallen from the effect of the shock, but immediately got up and walked, with the pistol in his hand, about half a mile, over two fences, to his home, and laid himself upon a lounge, telling his family that he had shot himself. He was intelligent, and answered all questions rationally for twelve hours after, with but trivial signs of injury. He was conscious twenty-four hours, but from this time he gradually became confused in mind, and sank by degrees into a state of coma, and died forty-eight hours after the infliction of the injury. The *post-mortem* showed that the ball had passed through the skull, and had traversed the cerebral structure in a lateral direction, slightly downward, and was found embedded in the anterior lobe of the right hemisphere of the brain, within an inch of the mesial line.

I select these cases from others of similar character on account of the illusory calm that soon followed upon the shock, and as likely to lead from this to an erroneous prognosis. It does not follow, however, that a favorable condition, moral and physical, of a patient soon after the receipt of a severe injury is always the precursor of an untoward termination. Persons of a naturally strong physical constitution, of strong will, and possessing a character full of courage, sometimes tolerate, without serious manifestations, severe local injuries, and pass safely through the different phases of restoration.

Another variety of latent shock, where there are extensive marks of external injury, and where the signs of collapse are trifling in comparison with the amount and extent of the lesion, is typically illustrated by the following case:

At the battle of Spottsylvania, during the recent civil war (May, 1864), I saw a soldier brought in on a stretcher to the surgical head-quarters, Ninth Army Corps (Burnside's), immediately after he was wounded. The mutilation from the explosion of a shell was frightful. Both lower extremities—one below the knee, the other through the lower part of the thigh—were shattered, hanging only by shreds of skin and muscular tissue. The right arm above the elbow was in a similar condition. This man possessed his intelligence perfectly, conversed about himself, and related that the first intimation he had of being injured came to him when, finding himself on the ground, he made efforts to raise himself with his right arm, and feeling his inability to do so, turned his head toward that side, and found it bloody and shattered. The signs of collapse were so little marked that amputation of the three limbs was gravely considered. Such cases generally sink gradually, terminating in low muttering delirium, coma, and death. The suddenness and intensity of the shock seem to put a stop to the farther elaboration of the nervous power by the central ganglia, and in proportion as the surcharge distributed among the nervous trunks and branches and other tissues becomes exhausted, the vitality is slowly annihilated.

In the case of the soldier, the cause of death was asthenia, that is, death beginning at the heart, from nervous depression and want of power of the organ to propel its contents. In the case of Poole, the bullet was embedded in the muscular tissue of the ventricular septum, and extensive pericarditis was developed in the progress of the case, accompanied by much effusion into the cavity of the pericardium. He died from asthenia, or death beginning at the heart, the pericarditis and effusion complicating and aggravating the primary effects of the shock, which, from its intensity, may have also changed the character of, or to a certain degree devitalized, the blood.

Fisk died from a combination of asthenia and coma, or from death beginning at the heart and at the head, but might have died from asthenia

alone, or death beginning at the heart, had he not been overwhelmed with the cumulative toxic influence of the narcotic drug too freely administered. The *post-mortem* revealed, among other pathological conditions, serous effusion on the surface and in the ventricles of the brain.

The case of pistol-shot of the brain, and that of fracture of the cranium with depression of bone, are instances of coma, or of death beginning at the brain, the act of respiration gradually ceasing to be performed as the functions of the brain and medulla oblongata become destroyed.

Complicated Shock.—There is another variety of shock, which may be called *complicated*, from the insidious merging or mingling of intercurrent sources of trouble with the original symptoms which strictly appertain to and are dependent upon the shock of the primary injury. For example, a soldier receives a traumatic lesion near the ankle from a fragment of exploded shell. The solution of continuity is not larger than a silver dollar or the palm of the hand, but the tissues are contused, ecchymosed, and injured down to the bone, which also seems to have suffered. The shock is not severe, and soon passes off, succeeded by a passive and moderate reaction. The functions of the several organs are performed well, the skin is cool, may be slightly moist and flabby, the tongue is moist and clean, the circulation and respiration about normal, the intelligence not apparently affected, and the person may feel well enough to express a desire to attend to business affairs. The wound, however, is not of a healthy character, the process of exfoliating the killed tissues on some parts of the wound is inactive, granulation does not progress, the wound looks glassy, pale, with a thin ichorous discharge coming from the surface, there is transudation of venous blood from the wound, and the edges show no signs of reparation. There is but little pain about the local injury, and, in fact, but little inconvenience is felt from it. Sometimes, however, from the second day to the third or fourth week, the scene changes. The patient becomes irritable and restless. He will have repeated chills, followed by a hot skin, and again succeeded by a viscous sweat. The expression changes, the adnata begins to present a yellowish hue, the skin assumes a dull icteric color, and is hot and dry. The respiration is more rapid, the pulse becomes frequent and quick, the tongue

dry and furred, and the physiognomy stupid, uncertain, anxious, and staring. We have here a series of symptoms indicative of blood-poisoning from the wound, added to the primary effects of the original injury. Such a condition is not unfrequently met with after important surgical operations, as well as from injuries received by accident, and when once fully developed is frequently followed by a fatal termination. The symptoms just cited correspond to those in the case of the late Captain E——, who was wounded at the first battle of Bull Run, July, 1861, and was brought on to New York for treatment. He was struck by a portion of an exploded shell on the outside of the ankle, tearing off the gaiter and shoe, and producing an irregular contused solution of continuity nearly as large as the palm of the hand, and injuring the tissues severely as deep as the osseous structure. The os calcis was laid bare, and also contused. The general symptoms for a time were favorable, but the wound never had a healthy aspect. During the fourth week from the time he was injured venous bleeding took place from the wound, and a chill ushered in symptoms of purulent infection, from which he rapidly sank, and died on the third day after the attack.* A partial *post-mortem* examination only was permitted: pus and coagulum were found in the veins leading from the wound. In this case the length of time between the traumatic injury and the fatal result was such as to leave no doubt as to the cause of death; but in some instances the untoward result takes place so soon after the accident that death has been attributed to the nervous influence of shock alone. The following case is related by M'Clellan, of Philadelphia, as an instance of what he calls "insidious shock," referring the symptoms to the nervous impression received at the time of the accident: "One of the most striking cases of this kind of shock I ever knew occurred, about twenty years ago, in the person of Mrs. S——, the very beautiful and delicate wife of a Portuguese merchant, then resident in this city. She had been upset in a buggy from a too rapid turning of the horse, and on attempting to leap out at the instant of the overset, she produced a bad compound dislocation of her right ankle inward, and a comminuted fracture

* For particulars of Captain E——'s condition before I saw him, I am indebted to Professor W. Detmold, who had the case in charge from the beginning.

of the lower portion of the fibula. Her family physician was so struck with the condition of her system that he had me called into consultation on the *third* day. I found her perfectly free from pain and febrile action, with a soft and tranquil pulse, and natural respiration. Her tongue was clean but quivering, and the intestinal, urinary, and cutaneous secretions had gone on very well. But the wound had neither adhered nor inflamed. The parts had become slightly pulpy, and discharged a thin sanies, without any attending inflammation or disagreeable odor. Her skin, however, presented an orange hue, and her countenance expressed great fright or alarm, although her mind was perfectly composed. The points which I have aimed at in the text were exactly marked in her face. She was composed and smiling about the lips, but suspicious and threatening about the eyes and forehead. Every time I came up to her bedside she would stare at me with corrugated brows and wrinkled forehead, with an expression of apprehension and astonishment or surprise. I of course gave an unfavorable prognosis; and although every attempt was made to sustain her by moderate stimuli and cordials, she rapidly declined into irretrievable exhaustion. The *next day* (the fourth) I found her respiration hurried and irregular, her countenance more anxious, although she was still destitute of fever and delirium. The ensuing night, however, she became flighty; her heart palpitated and fluttered; she fell into twitchings or convulsions, and died before the occurrence of mortification, or even of decided inflammation." The grave symptoms which are here described were rapid in their appearance, and certainly progressed in a very insidious manner, but they were undoubtedly caused by the supervention of blood poison, originating from the wound, and not by a new series of pathological changes directly taking place in the nervous centres through which the shock primarily operated.

Cases of similar character occur at times in private practice, but are more frequent in hospital wards, where patients are sometimes overcrowded, and the air less pure and wholesome. A lady with scirrhus of the breast came from Maryland to consult me. I performed the operation for removal on a Monday. On the second night after, the patient was attacked by a chill, hard cough, and pain in the right side with difficulty of breathing. On

the third day there was fever, hot, dry skin, wild and staring expression, with glassiness of the eyes, the adnata tinged yellow, restlessness and loss of appetite, quick, irritable pulse, and wandering intellect. The difficulty of breathing and other symptoms of toxæmia rapidly increased, and the patient died on the fifth day from the date of the operation. About the same time I operated on a case of lithotomy in the adult male, by the bilateral section of the prostate, in the State Emigrants' Hospital. The patient was attacked, on the third night after the operation, with cough and restlessness, and difficulty of breathing. A similar train of symptoms occurred as those mentioned in the breast operation, and the patient died on the fifth day after the extraction of the stone. In both cases, examination of the cadaver showed evidences of purulent absorption in the lungs, and there was also effusion into the cavity of the pleura; in the case of scirrhus, on one side, and in the other, on both sides. In both instances the character of the wound was unhealthy.

It may be supposed that toxic effects from a traumatic lesion cannot take place at so early a period as that just stated after solution of continuity has been produced. Septic material can be furnished from an unhealthy wound within less time than forty-eight hours after it is received, and can be rapidly introduced into the general circulation by the veins and lymphatics. Purulent infection may occasion death soon after it has taken place, but generally six, eight, or twelve days elapse before the termination of this disastrous complication. At times, the symptoms are prolonged for some weeks, with signs of amelioration and hope, but these are often deceptive; in fact, the prognosis is not favorable when patients become affected with this grave intercurrent event. I may add here, that the cases of rapid dissolution occurring from two to eight days after injuries with shock, while apparently progressing favorably, are frequently to be attributed to toxæmic infection associated with an unhealthy morale and a cachectic diathesis.

The entrance of morbific material into the circulation, and the alteration which consequently takes place in the blood, produce a series of adynamic and typhoid symptoms in the general system, which, taken collectively, have

been designated by different names. This nomenclature has generally been based on the supposed etiological theory of the cause from which the pathological condition is supposed to have originated. The names generally used to express this condition are phlebitis, pyæmia, and septicæmia: other names also have been applied, as purulent infection, purulent absorption, purulent metastasis, and purulent diathesis. With the diversity of designating terms, the paramount fact is always acknowledged that a poisoned condition of the blood is the source of the various depressing and pathognomonic symptoms. If any addition were to be made to the classification of the different modes of dying as already adopted by Bichat, the train of morbid phenomena resulting in death from blood-poisoning would be readily accepted as a distinct mode of dying, considered apart from death beginning at the heart, at the lungs, and at the head. Certain it is that after serious accidents and surgical operations, and the traumatism following parturition from the separation of the placenta, and the usual laceration of the cervix uteri, vagina, and fourchette, a class of symptoms varying in grade and intensity often arise, which terminate in death. It has been proposed to draw a line of demarcation between pyæmia and septicæmia, basing the differential diagnosis upon the invariable presence of an increase of heat as denoted by the thermometer, and by the absence of recurring chill during the progress of septicæmia. The symptoms as described, even by those who advocate this distinction, are, in a great degree, common to both, and, without leading to any practical error, may be considered as varieties only of the same disease. The difference in the abnormal manifestations resulting from poisoning of the blood should be viewed as generical, and the term toxæmia be selected, in preference to any other, as not implying in advance by technical denomination the special nature of this morbid condition. The words septicæmia and pyæmia should be regarded as expressing specific varieties of toxic invasion. Numerous authorities might be cited who advocate the exclusive influence of the absorption of pus, originating from the surface of a wound or from the inner coat of the veins, with or without an embolic deposit of coagulum, as the cause of typhoid or septic disease, while others of equal merit dwell upon the putrescence that takes place after labor from the decomposed

coagula in the cavity of the uterus, and from the thrombi in the venous sinuses, as being the sole primary cause of the various typho-adynamic conditions which often follow upon child-birth. There is a diversity of causation in the sources of blood-poisoning, and it follows that there should be some variety in the correlative symptoms. As a general rule, the symptoms of pyæmia are more commonly met with after traumatic injuries and surgical operations, while those of septicæmia are more frequently present in the toxæmic puerperal maladies. But the placental surface of the recently delivered womb and the uterine venous sinuses may furnish pus as well as the peculiar putrescent material at times present in the cavity and walls of the uterus. With the compound poison derived from this source, another modification of symptoms takes place, different in character, and marked by more intensity than those met with in either of the other forms of toxæmia. The inhalation of the impure air of hospital wards, absorbed through the lungs into the circulation, is also a source of toxic influence to the blood, and becomes a predisposing cause of purulent and septicæmic infection. It may be mentioned here, although not immediately connected with the primary effects of injuries, that there exists a self-producing blood poison that originates within the system, and is capable of producing septic symptoms analogous to those of more obvious origin. This idiotoxic influence, described by Virchow, emanates from disintegration of structure, terminating in a pathological process, which he calls necrobiosis, to designate a latent disorganization or death of tissue in the organs. By a somewhat similar process of change, the concussion or shock incident to severe accidents is sometimes remotely followed by disorganization of structure of some part of the organism, the origin of which may be referred back to the antecedent injury. The fluids of the body are also subjected to a morbid metamorphoses, which may produce idiopathic blood-poisoning.

The introduction of infusorial molecules into the circulation, through the medium of the lungs or by direct transmission from the surface of a traumatic lesion, is believed to be the cause of changing the character of the blood, so as to render it highly poisonous to the system, and productive of highly nocuous toxæmic disease. The purulent ophthalmia of armies and of

public institutions, where large numbers of adults or children are crowded into badly ventilated wards, is known to be caused and maintained by the implantation of cryptogamic particles upon the palpebral conjunctiva.* By the aid of the microscope, a species of algæ, termed bacteria, has been found in septicæmic blood, and which has been regarded as the source of the characteristic symptoms of toxæmic disease. It has been asserted, however, by some experimenters, that these products were the effect of the morbid changes already taken place in the blood, and not the cause of its toxic condition. Experiments lately made by M. Pasteur, and recorded in a paper read by him before the Académie de Médecine of Paris, seem to prove that infusorial bacteria, when introduced into the circulation of some of the inferior animals by injection, are not only deleterious in their effects, but, in some instances, rapidly produce death. The subject is one of great importance, and is again claiming the attention of scientists.†

Purulent infection, then, is a complication of wounds from external injury, or from the incisions of surgical operations, and probably, as has been stated, is developed at times spontaneously. Whether from putrid infection, or from purulent absorption from the surface of a wound, or from the admission of pus into the circulation secreted from the calibre of inflamed veins, a group of symptoms may suddenly supervene, after an accidental or intentional wound, which frequently are the harbingers of a fatal termination. These symptoms often do not show themselves before the expiration of ten or twelve days after the occurrence of the lesion. Sometimes they are developed as late as the second or third week, but, at other times, they are abruptly ushered in as early as the second, third, or fourth day, and occasion death

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* When first appointed as Surgeon-in-Chief to the State Emigrants' Hospital, I found, grouped in badly ventilated wards, about 350 children and adults affected with purulent ophthalmia. The disease had been contracted by many of them in the crowded transport sailing vessels, which had brought them from the old countries to America. It was introduced first into the hospital by the new arrivals from the ships, and kept up there by overcrowding and badly regulated accommodations. The number of blind had so increased during the four previous years as to create discussion and anxiety with the State authorities in regard to the future support of those thus rendered helpless. The disease readily yielded to the adoption of improved hygienic measures, and to the rapid application of the solid stick of nitrate of silver to the everted granular palpebræ, immediately followed by the use of a camel's-hair brush dipped in a neutralizing solution of muriate of soda. The disease was undoubtedly of infusorial origin.

† *Vide* Report of the Académie de Médecine, Paris, March, 1878.

within forty-eight hours after the receipt of a traumatic lesion. During the night of the third or fourth day after amputation of the breast, for example, I have seen patients suddenly seized with a chill, and dry hacking cough, heat of skin, and pain on one side of the chest. The adnata would soon become icteric, and the other preliminary symptoms indicating purulent infection would appear, the patient gradually becoming overwhelmed, and dying within forty-eight hours from the appearance of the unfavorable symptoms. A hospital patient was treated for extensive varicose veins, in one of the wards of the hospital, by the use of the figure of 8 ligature with the introduction of several needles under a group of enlarged veins belonging to the internal saphena, at the upper and inner part of the leg. On the third day signs of purulent infection presented themselves, and he died suddenly on the fifth day. Pus was found in the veins, and small purulent deposits disseminated on the surface and in the substance of the lungs.

It is not necessary that there should always be an external solution of continuity, for a bone may be fractured and split near a joint, inflammation and suppuration may occur on the surface and in the spongy osseous texture, and be followed by purulent infection and sudden death, an instance of which has recently come under my observation.

If, on making the morning visit on the third or fourth day after a lesion has been received, a patient who has apparently been doing well the previous day is found with the adnata beginning to assume an icteric hue, with the countenance more or less stolid, the skin slightly yellowish with reddish streaks, the lips pale, and the eye staring with glazed expression when spoken to, and the skin covered with an abundant sweat, these signs being ushered in by a chill which has lasted from a quarter to half an hour, such change assumes a serious import, and the prognosis becomes decidedly unfavorable. If these symptoms continue unchecked the heat of surface now returns, and the sweating stage may last one or two hours, and this accession, during which the pulse may have been normal or but slightly accelerated, is followed by calm and a general amelioration. Sometimes two or three of these exacerbations occur during the twenty-four hours, and if the case is prolonged they may simulate the type of intermittent fever, the chill coming

on periodically at the same hour. While these constitutional signs are apparent, the solution of continuity remains indolent and pale, the suppuration is less in quantity, and the pus assumes a sanious and fetid character. If the case be one of amputation by flap operation, and the line of incision has partly united, the adhesion gives way and separates, and the flaps are ashy and flabby. As the malady progresses, the countenance, changed from the first, becomes more altered, the skin is leaden or more deeply tinged with yellow, and at times covered with sudamina. The conjunctiva, like the skin, assumes a deeper icteric hue, the constitution also shows signs of being more deeply impressed, the patient is overcome with a sensation of debility and prostration, the torpor is increased, and he remains in a half-sleepy condition, oppressed with continual agitating dreams, and confused by a vague and passive delirium which is augmented during the night. If spoken to abruptly, however, he will become aroused, and if interrogated will answer correctly any questions that may be addressed to him.

The general perturbation in the system goes on increasing, the respiration generally is accelerated, the inspirations, running up to thirty or forty in the minute, are full and deep without stethoscopic abnormal signs. Often, however, there is a hacking cough, accompanied by expectoration of yellowish, frothy sputa, at times tinged with blood, or presenting the iron-rust coloration of pneumonia—these symptoms being generally pathognomonic of the presence of metastatic abscesses in the lungs. These pneumonic symptoms are often preceded by or associated with sharp pains on one side of the chest, indicating that the pleura has participated in the inflammation of the lung. A similar pain is sometimes felt in the region of the liver, also indicative that the inflammation which surrounds the metastatic collections of pus has extended to the peri-hepatic serous membrane. The pulse at this stage of the malady is rapidly running down, and is small, frequent, and easily compressible. The functions of the digestive organs are much disturbed. In the commencement of the attack, the tongue, which was soft and humid, and covered with a whitish coating, has now become loaded with a dark-colored sooty covering. There are sordes on the teeth, disinclination for food, and at times diarrhœa.

Not unfrequently patients who have suffered from the foregoing series of symptoms will be seized with a severe pain in some part of the body, often in the vicinity of a joint, such as the knee, ankle, elbow, or wrist, or the pain may be felt on the trunk, or along the course of the neck and extremities. This pain is so acute at times as to preoccupy the mind, making it the only source of complaint, and superseding all the other signs which belong to purulent diathesis or infection. If the painful spot be examined, a doughy, puffy, œdematous swelling will be perceived, ordinarily not larger than a split walnut, that has its seat in the subcutaneous cellular tissue. The skin soon becomes red, and fluctuation is perceptible, the swelling assuming the character of a phlegmonous abscess. At other times the purulent collection forms in the articulation, and the capsular sac of the joint becomes distended and painful, and the movements are impeded, and ultimately completely suspended. It may be here remarked that patients dying from purulent infection frequently exhale a disagreeable and peculiar odor. Finally, the depression increases, the torpor and stupor run into coma, the respiration and circulation become more and more embarrassed, and the patient expires. In this malady, from the commencement of the attack, announced by the first chill, life is seldom prolonged beyond the twelfth day. Sometimes a deceptive calm intervenes after the initial chill. Two, three, or more days may elapse without any return of chill. This lull in the symptoms may indicate a favorable turn in the disease, but experience has proved that the symptoms of purulent infection will usually return, and very frequently destroy the patient. I have observed recoveries take place where the metastatic abscesses were confined to the subcutaneous cellular tissue of the extremities, the parenchymatous organs remaining exempt from the purulent infection. Although the fatal termination of this complication of external injuries may be delayed, as before stated, at times, the disease progresses with rapidity, and the patient perishes suddenly, within twelve or twenty-four hours from the commencement of the symptoms.*

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* I have introduced the subject of purulent infection as a complication of shock and collapse at some length, as it occurs, at times, as such, and is incorrectly regarded as a group of symptoms belonging to the primary nervous impression of the injury. The medical attendant, when made aware of the fact, must diagnosticate for himself.

A complication of shock at times arises that is characterized by an aberration of the intelligence distinguished from other forms of delirium by its exciting cause, which is ordinarily one of external violence, by its freedom from fever, and by the analogy which it bears to delirium tremens, or to that condition of the nervous system which is brought on by the excessive use of intoxicating drinks. Dupuytren, who first described this morbid state, designated it by the name of nervous delirium—"délire nerveux"—and more recently, from its association with severe injuries, it has been called traumatic delirium. At times this kind of nervous delirium is developed suddenly during the first days after the occurrence of an accident, or the invasion may occur less rapidly, and be preceded by certain signs that serve almost as infallible precursors. This complication of shock from external lesions is met with most frequently in persons of broken-down constitutions the result of excesses either mental or physical, in those of nervous temperament, of timid disposition, and of excessive impressionability to external influences. It appears commonly as a consequence of fractures or dislocations, or of severe injuries of any kind, or as resulting from extensive wounds, or from surgical operations. Although generally occurring within a brief period of the accident, it may show itself at any time during the progress of such injuries as those just mentioned, or toward their termination. It is met with more frequently in hospitals than in private practice, in men more often than in women, and is rarely or never seen in the very young.

When in Paris, as a student, following the clinical lectures of Roux, Blandin, Nélaton, Velpeau, Gerdy, Bérard, Bouillaud, Piorry, and of other great masters in surgery and medicine, the subject of toxic infection was receiving much attention. At that time it was the custom at the Hôtel Dieu, at La Charité, La Pitie, and the other large hospitals, to dress wounds after surgical operations so as to heal by *second intention*, filling the wound with charpie spread with a simple cerate. It was very common to see patients thus treated attacked with purulent infection. The overcrowded wards, also, in those hospitals, particularly during the cold season, favored the development of toxæmic disease. In the remarks on the progress of purulent infection and nervous delirium, I have made use of some notes taken at the clinique of M. Nélaton.—*Vide* Dupuytren, "Leçons Orales;" Velpeau, "Médecine Opératoire;" Sédillot; P. Bérard, article "Pus," du *Dictionnaire de Médecine*, en 30 volumes.

During the first period of my service, from 1850 to 1865, at the State Emigrants' Hospital, owing to the accumulated number of immigrants throughout the country, the hospital was always full, and many cases requiring surgical operations were admitted. For two or three years, partly on account of the overcrowded condition of the wards, cases of purulent infection frequently occurred. Afterward, in operations, I adopted the plan of the early removal and changing—within twenty-four hours—of the first dressing. Such cases rarely occurred in amputations after this. This subject will be considered under the head of "Treatment of Shock and Collapse."

In cases of nervous delirium, the brain, already before the accident predisposed to unnatural impressionability, soon after the receipt of the traumatic lesion, begins to manifest signs of functional disturbance. Upon the receipt of a shock, the reflex function of the nerves transmits various impressions to the important organs. It naturally follows that the effects of an injury will influence the vital properties of the brain as well as of the other more remote and distant organs, and by reason of the communication of the commissures derange its functions and arouse into activity the latent susceptibility to receive new morbid impressions by which cerebral irritation is produced. The derangement of the principle of innervation once established, the increased ingress of blood into the parts now suffering from morbid irritability tends to augment and sustain the morbid action there present in the form of traumatic delirium. In this etiologic description the point of inflammation has not been reached, but the brain is placed in the dangerous condition that leads to serous effusion. The symptoms are in accord with the pathological condition of the encephalon. As there is no inflammation there is no fever, and the objective signs indicate and point out the organ or organs of the brain where the irritation is most concentrated and intense, according as the intellectual faculties, the sentiments, propensities, or special senses are most ostensibly affected and perturbed. For example: a mechanic while at work becomes entangled in machinery, and has a limb crushed and fractured. He receives a shock, followed by collapse. He is removed to a hospital, or sent to his home, and a moderate reaction comes on in the course of twenty-four hours. Signs of nervous delirium begin to show themselves, and within forty-eight hours he is out of his senses. This man has been overworked, he has been badly fed, and, besides working in an unhealthy, overheated factory, he sleeps in an unwholesome and badly ventilated chamber, and has few home comforts. While his general physical condition is thus unsound, his brain and nervous system have been specially overtasked. The organs of vision and of hearing have been continually, while at his work, in a state of prolonged overaction, and, moreover, he may be a political agitator or a Communist, and in continued excitement about the wrongs which capital has inflicted on labor; with him *la propriété c'est*

le vol. If the entire brain be not in a state of undue excitability, such a patient will probably see all kinds of imaginary objects and hear unusual sounds. He will be violently combative, from his supposed unsatisfactory social condition, muttering incoherent sentences, and raving about subjects that had preoccupied his mind before the accident. The shock has been carried to the cerebral ganglia, and thence reflected upon those portions of the brain most ready to take on diseased action, and so the symptoms may be varied according to that part of the brain most likely to give way, or to be brought into pathological activity. This affection is very much allied to delirium tremens, and if the cause of the antecedent abnormal cerebral impressionability has been the free use of alcoholic stimuli, the symptoms of delirium may become manifest within a few hours after the shock has been received. Hospital and army surgeons are apt to be familiar with this kind of complication, but it is often met with in private practice.

Persons who have had a severe shock from any external cause are liable to this complication. It becomes developed after attempts to commit suicide, after important surgical operations, or after extensive and dangerous lesions. The symptoms begin to show themselves often as soon as the night following the occurrence of the shock; at times not until twelve, twenty-four, or forty-eight hours have elapsed. The patient from being comparatively comfortable will become restless, and make abrupt and sudden movements with the head and arms, catching unmeaningly at the bed-clothes. His eye will become more vivid, and assume an expression unnaturally inquisitive and suspicious. He will continue speaking and muttering short and incoherent sentences. The intelligence becomes confused about surrounding objects, and some prominent idea about his occupation, his tastes, habits, age, or sex, seems to control and preoccupy the wandering mind. There is continual jactitation and inability to sleep. The head, face, and neck are covered with profuse sweat. The eyes become brilliant and congested, the countenance excited and flushed, the patient grows violent and unmanageable; he keeps uttering angry and menacing expressions of ill-nature, and sometimes of revenge. The general insensibility is so great that a patient with a fracture will, if not restrained, tear off the retentive bandage, and jump out of bed,

moving hurriedly across the room, heedless of the dangling limb, and apparently unconscious of pain, or, after an amputation, will throw himself out of bed, as if making efforts to escape from the attendant.

The constitutional symptoms are not in correlation with the commotion and perturbation of the nervous system. The pulse is comparatively tranquil and natural, and the action of the heart is not increased beyond the influence of the restlessness and jactitation. There is no change in the regularity of the functions of secretion and excretion, but digestion is suspended. The appetite is gone, and if food and drink are urged upon the patient he will eject them from the mouth with violence and temper. This condition lasts for two, three, or four days, and terminates either in restoration or in death. When a favorable result takes place, the symptoms subside as abruptly as they appeared; profound sleep, which had fled from the patient, takes possession of him, and at the end of ten or fifteen hours he awakes, feeble, but sensible to pain and to his condition, in possession of his intelligence, and without any recollection of what he has just passed through. The appetite becomes re-established, the original injury takes its natural course toward recovery, and the case progresses thenceforth without complication. Sometimes this kind of delirium may be renewed by two or three consecutive attacks, after one or two days of remission, the disease subsiding gradually, and each subsequent relapse becoming milder in character.

Delirium tremens, or *mania a potu*, is another complication occurring after injuries attended by shock and collapse. This affection is a magnified type of "nervous delirium," marked by symptoms of greater severity, and is the form of this variety of mental disease to which confirmed and habitual drunkards are most liable. It occurs more frequently among nationalities where the habit of freely using strong alcoholic drinks is prevalent than with people who are accustomed only to the milder beverages procured from malt or from the grape. In both of these remarkable cerebral conditions, the latent morbid predisposition engendered in the nervous system by prolonged and abnormal stimulation is evoked or brought into activity by the depressing influence of the shock. *Mania a potu* is ushered in usually within the first twenty-four or forty-eight hours after the receipt of an injury, by general

inquietude, restlessness, tremor, unnatural watchfulness, incoherent loquacity, and mental illusions, often with a frequent pulse, cool skin, and perspiration. There is wakefulness, insomnia, an anxious expression of the countenance, tremor of the hands, and of the tongue when extruded for examination. There is a strange expression of alarm and suspicion about the eyes, which glance rapidly around from one object to another as if desirous of eluding an anticipated danger or injury. The perturbed mental condition goes on increasing, although the patient may assert that he feels well. He continues to speak hurriedly and irrelevantly, and is tormented with a succession of hallucinations assuming the character of alarming and ludicrous apparitions. Snakes, dogs, elephants, flies, and other animals appear to his disordered imagination, disgusting objects are seen crawling over the bedclothes, and he supposes, at times, that persons have entered his apartment to injure or to kill him. In order to avoid such imaginary dangers he becomes greatly agitated, cries out aloud for help, or threatens and raves in the most violent manner. Strange noises haunt his fancy, he hears sounds around him, or refers them to an adjoining chamber. His mind and body are in continued agitation and activity. He picks up supposititious objects, such as coin or pins, calls out to some imaginary person, starts with terror from some frightful phantasm, assails those who take care of him, and insists that they are confining him for sinister motives. If contradicted, he becomes exasperated, although at times, if dealt mildly with, he may answer questions reasonably, and for a while be manageable without restraint or coercion. Often, however, as the disease progresses, the patient becomes furiously delirious, and can with great difficulty be restrained from inflicting violence upon himself or upon others. He loses all recognizance of his attendants or friends, and at this stage, if not closely watched, will accomplish self-destruction in one way or another. As in nervous delirium, patients thus attacked after injuries are strangely insensible to pain, tossing about or jumping from the bed with a fractured or amputated limb, if not restrained, and insisting upon renewing their business occupations. The pulse varies according to the character or temperament of the individual. In some instances it is full, hard, and frequent; most commonly it is soft, full,

quick, and without tension. The skin is sometimes above the ordinary temperature, at others natural and moist. There are signs of gastric disorder, with loathing of food, and excessive craving for cold drinks. The duration and degree of violence of delirium tremens vary in different persons according to the habits, temperament, and amount of antecedent excesses. It is a complication much to be dreaded, from the additional dangers it entails upon a patient already suffering from the effects of shock and collapse resulting from antecedent injury. The disease, if slight, often passes off in a day or two; if more acute, the symptoms continue unabated for five or six days or longer, remitting somewhat during the day, and showing exacerbation at night. In aggravated cases the symptoms become more severe, and assume the character of wild and ungovernable mania, ending in cerebral effusion, convulsion, coma, and a final fatal apoplectic sleep.

Under the head of complicated shock may be placed those cases of sudden or rapid death that take place unexpectedly, and while the patient has been to all appearance progressing favorably. Persons so severely injured as to have the nervous system impressed by shock may, at the same time, be already suffering from angina pectoris, or from some cardiac affection, and suddenly die. It is not intended here to classify under this head such chronic cases, or the group of phenomena associated with pain and other chronic morbid symptoms in the chest ending in sudden death, and which simulate angina pectoris.

The change in the blood and the perturbation of the circulation that take place after severe injuries may lead to congestion of the right side of the heart, producing paralysis from overdistension, or spasm of the muscular tissue of that organ, causing unexpectedly syncope and death. Thrombosis of the pulmonary artery and embolism of the heart are known to cause death suddenly in the puerperal state from inopexia, and hyperinosis of the blood, as intercurrent complications.* A similar condition of the system may take place soon after the receipt of severe injuries, or a latent hyperinotic predisposition may have been already established in the circulation previous to the time when the injury occurred, favoring the deposit of coagula incom-

* *Vide* Essay by Sir James Simpson, 1854.

patible with life in the large vessels and in the heart, now thrown into a state of asthenic action as a consequence of shock and of the depression and collapse of the nervous power. The following case, which proved, upon *post-mortem* examination, to be one of rapid death occurring from embolism and thrombosis of the heart and pulmonary artery, confirms this statement, and shows the possibility of such a condition existing already in the system at the time of injury. I saw the patient, and found him in a state of collapse simulating that of Asiatic cholera, on the evening of May 6, in consultation with Dr. Maclennan of this city, and transfer his notes, taken from the period of the accession of the symptoms until the fatal termination.

"Case.—M. H. K——, æt. 38, of sanguineous temperament, about midday on 5th May had a sudden feeling of faintness, and appeared so ill as to cause his friends to think him dying, and to send for medical assistance in all directions. Apparently his distress was in consequence of an attack of diarrhœa, with vomiting, which had existed from 8 A.M., accompanied by severe abdominal pain, especially in the right iliac region. Not being at home when the message arrived, I did not see him till about 3.30 P.M. In the mean time another physician had arrived, and treated him with external applications of mustard and hot water, with a subcutaneous injection of ten drops Magendie's solution of morphia, and an injection, per rectum, of fifteen drops of Tinct. Opii. He was somewhat relieved, but continued restless. At this time the pulse was 100, temperature in axilla 98°, perspiring freely, large beads of perspiration covering his forehead, hands and feet cold and damp, patient complaining of excessive weariness, and easiest while on his knees, with his stomach pressed against the sofa; 5 P.M., pain getting more severe, he had another subcutaneous injection of morphia, ten drops. This gave considerable relief, and he was able to lie in bed on his back. There was great tenderness over the bowels, especially in right iliac region; passed the night in a very restless manner, though not suffering much pain; he had two doses of ten drops each of Magendie's solution at intervals of three hours during the night. He never vomited since the first visit, took considerable quantities of beef tea, yet the coldness of feet and hands and other symptoms of collapse continued the same. Hot water in bottles

was kept constantly applied to the hands and feet, without having apparently any effect. Monday, 6th, 8 A.M., no improvement—still in collapse; pain not severe during the day; pulse varying from 120 to 130, and very feeble, although quite regular, temperature in axilla 95°, tongue moist, although complaining much of thirst. As he continued so depressed, at 3 P.M. I began to give Champagne, which made him feel much better, although without causing any improvement either in pulse, temperature, or coldness of hands and feet. At 9 P.M., Dr. Carnochan was called in consultation, and it was decided to apply a fly-blister for two or three hours to right iliac region, for the purpose of obtaining its stimulating and revulsive effect, and to give twelve grains of calomel, also a grain of carb. ammon. every two hours, with a beef tea injection containing two grains of carb. ammon.; Champagne to be continued. Until 2 o'clock A.M., 7th, he remained very much in the same state, but at this time he had every appearance of dying; pulse feeble, and 160 beats to the minute; respirations short and hurried, and 38 per minute. During this time patient's intellect remained clear, and he expressed himself confident of recovery; hands and feet very cold and clammy. Champagne was freely given, and constant rubbing of hands and feet kept up for about two hours, when the pulse began to be less frequent, and came down to 140; respirations decreased in frequency to 28. At 8 A.M. he appeared better, the blister having risen well; he had had two motions from bowels of dark color and very offensive odor. At about 3 P.M. administered an injection of soapy water, with a table-spoonful of turpentine, as the bowels were much distended. This gave great relief, and patient did not complain of abdominal pain any more. About 5 P.M. patient's face became flushed, and the temperature in the mouth went up to 105°; hands and feet less cold. Breathing again became short, accompanied by a short, dry cough, which caused the patient much pain. Symptoms of pneumonia, especially over right lung, were now becoming very marked. No sputa. Sound of heart muffled. The first sound scarcely audible; the second feeble; embolism and heart-clot suspected. Applied turpentine stupes over front of chest, changed from Champagne to brandy milk punches, as patient was tired of the former, although he had not vomited. Calomel had been re-

peated—carb. ammonia continued. During Wednesday, 8th, he continued in the same state, except for a tendency to wander in his mind, and to talk continuously about his business affairs, very restless all day, and could hardly be persuaded to stay in bed, continuing thus all night up to Thursday morning, 9th; pulse 120 to 130 through the night, changing frequently. He seemed to have difficulty in recognizing any one. Suddenly, at 8 A.M., he rose up out of bed, and stood on the floor, struggling as if he felt himself being held down, his eyes were fixed, looking straight before him and a little upward. He then, in a loud, strong, and distinct voice, called out *murder* about twenty times, his face getting paler all the time, and assuming a most anxious and distressed look. Appearing to be exhausted by this effort, he made no objection, but rather attempted to get back to bed, where, after giving two or three gasps, and his face rapidly becoming purple, he quietly died. The whole time occupied from his getting out of bed until he died being about thirty seconds."

Post-mortem.—At the *post-mortem* examination several small patches of inflammation were found on the small intestines. There was no obstruction in any part of the alimentary canal. The stomach, liver, kidneys, and other abdominal organs were all healthy. In examining the chest, both lungs were found congested and engorged with blood. The heart was normal in position and size. On laying open the right ventricle a large fibrinous clot was found, nearly filling the cavity of the ventricle, and continued into the trunk of the pulmonary artery and into its primary branches to the extent of several inches. The entire length of this coagulum or clot, after being removed and allowed to remain in water for a short time, presented a yellow, buffy, fibrinous appearance and character, and retained the shape, as if cast or moulded in the ventricle and pulmonary vessels. There was a small fibrinous clot in the left ventricle. The auriculo-ventricular valves and those of the aorta and pulmonary artery were normal.

This case is most interesting from the fact that it was possible to trace its progress and symptoms from the first accession of the attack until the revelation obtained from the *post-mortem* examination. This man had been a free-liver, and was in the habit of frequently taking the Russian bath,

plunging into very cold water after being overheated with vapor. The day before his attack he had seen some friends off on a foreign steamer, had drunk freely and been otherwise dissipating, and had taken one of his favorite baths with the plunge. The light patches of inflammation observed on the small intestines were of trivial character, and could not be taken into account in the causation of death. There was great general distress from the first, and as the stomach was healthy, it is probable that the initial symptoms of abdominal pain and vomiting were the result of reflex influence from the cardiac nervous apparatus. The main symptoms in the case were those of collapse—restlessness, and a general feeling of great distress, rapid and short breathing, quick, frequent, small, and feeble pulse, cold surface, and clammy sweat. The muffled sounds of the heart were attributable to the play of the tricuspid and pulmonic semilunar valves becoming obstructed from entanglement among the embolic deposit, as it accumulated in the right ventricle and pulmonary arteries, and from the retarded pulmonic circulation and the diminished quantity of blood on the left side of the heart. There was a small deposit of coagulum in the left ventricle, and the general arterial system was anæmic. The functions of the brain were ultimately arrested, and, amidst evidences of great agony, death occurred from nervous exhaustion and asthenia. In fact, the general symptoms were very similar to those resulting from excessive loss of blood, such as cold and clammy surface, countenance pale and anxious, distress and restlessness, tossing in bed, short and rapid respiration, quick, small, and feeble pulse, anæmic surface, insensibility, delirium, terminating in death. Had this patient met with a severe injury shortly before the idiopathic attack, the embolic condition would undoubtedly have equally supervened, and afforded an instance of sudden death occurring as a complication of shock.

This hyperinotic state of the blood, leading to idiopathic embolism of the right side of the heart and of the pulmonary arteries, is more common than is usually supposed, and in many instances, during the progress of disease, or following upon severe injuries, becomes the latent and unsuspected cause of sudden or rapid death.

Besides the case just cited, two additional ones have lately come under

my observation, in both of which an opportunity was given of making a *post-mortem* examination. One case occurred where there were calcareous deposit and imperfection of the aortic valves, and atheromatous degeneration and enlargement of the ascending portion of the arch of the aorta, without, however, the general health being materially affected. The other took place as an intercurrent complication of abscess occurring at the caput cæcum coli, from the impaction of a portion of chicken bone inadvertently swallowed.

Case.—D—— M——, æt. 52, of sanguineo-nervous temperament and robust form, a plumber by occupation, became indisposed while at work on Thursday, 30th May last, with slight diarrhœa and giddiness, but continued to attend to business until Saturday evening. On Sunday morning, June 2, he dressed, intending to spend the day on a visit to some friends in the country. Not feeling well, he went to an adjoining restaurant to get some brandy, and while there fainted, and was taken home and put to bed. During the day he continued to feel faint and feeble, and showed no signs of improvement. At midnight he was suffering from great difficulty of breathing, but without pain; the countenance was expressive of great anxiety and uneasiness; pulse 140, temperature 101, respirations 40 to the minute, skin moist and clammy, hands and feet cold and damp. Ordered stimulants in the form of brandy and water, and milk punch. Carbonate of ammonia two and a half grains, and five drops of Magendie's solution every four hours. Sinapism to the chest.

Monday, June 3, 9.30 A.M.—Patient much easier, breathing without difficulty, although there is distinct mucous crepitation over both lungs. No sputa; pulse 140, temperature 101, skin moist, hands cold and wet; says he is much better; turpentine stupes applied over the chest. At midnight no change; tongue white and moist; no vomiting; has no desire for any thing but water.

Tuesday, 10 A.M.—But little change in the condition of patient; tongue more thickly coated, thirst very great, has no pain, skin has a dusky appearance, sleeps at short intervals, intellect clear. At 8 P.M., ordered twelve grains of protochlorid. hydrarg., to be followed by citrat. magnes. in the morning. Carb. ammonia continued.

Wednesday, 10 A.M.—Patient's condition much the same; medicine has acted; tongue cleaner; pulse the same; sounds of the heart are feeble but regular, and seem muffled and at a distance; hands cold and moist; still very weak; complains of feeling chilly, although the temperature of the room is 70; takes stimulants regularly. Although there is no improvement, says he feels much better; ammonia and Magendie's solution continued. At midnight, symptoms much the same.

Thursday, 10 A.M.—Temperature 97, pulse 148; respiration more rapid; hands cold and moist; sleeps at short intervals, and when waking has a startled and agitated look. Mutters incoherently, and wanders in his speech, but is sensible when spoken to; says he feels better, although evidently sinking. At 6 P.M. pulse becomes more feeble and quicker, other symptoms unchanged. At 7 P.M., while making a remark to one of his family, he turned over on the left side, and suddenly expired without a struggle.

Post-mortem.—The heart was found to be enlarged, and the muscular tissue soft and friable. The right auricle contained some semi-fluid and coagulated blood. The right ventricle was filled with a yellowish fibrinous deposit, with a layer of soft red coagulum partially covering it. This was easily washed off, leaving the tough yellow fibrinous deposit entangled with the tricuspid valve, nearly filling the cavity of the ventricle, and extending upward into the trunk of the pulmonary artery and into its two primary branches, so as to fill up and block their calibre. There was a small amount of red coagulum in the left auricle, and the left ventricle was partly filled with a soft dark red-colored clot. The ascending portion of the arch of the aorta was enlarged and lined with atheromatous degeneration, and the aortic semi-lunar valves were insufficient and studded with calcareous deposit. The lungs were greatly congested. There was some pleuritic effusion.

The following case of embolism of the heart and pulmonary arteries occurred as a complication of abscess of the ilio-cæcal region, resulting from impaction of a portion of chicken bone.

CASE.—M—— B——, an unmarried lady, æt. 37, of nervous temperament and excellent constitution, accidentally swallowed a piece of chicken

bone, which at the time gave some uneasiness that subsequently subsided, and soon the circumstance was almost forgotten. Paroxysms of pain, however, occurred at intervals over the abdominal region, and a general feeling of indisposition was complained of, but not sufficient to prevent her from attending to the usual routine of daily life. About three weeks after the bone was swallowed, the pain in the iliac region became so severe as to make it necessary to call in the family physician, Dr. J. S. Crane, with whom I saw her in consultation on the 10th of June last. I found her complaining of much pain in the iliac region, which increased upon pressure. A doughy or boggy sensation was imparted to the hand in passing it over the integuments of the hypogastrium. There was great distension of the abdomen, with tympanitis, rapid pulse, and restlessness. The mind unimpaired; skin dry and slightly above normal temperature; great thirst; no appetite. The patient thought so little of the swallowing of the bone that it was only by interrogations in that direction that the fact became known. From this, and the current symptoms, the diagnosis was reached that impaction of a foreign body in the appendix vermiformis or in the caput cæcum coli had taken place, producing abscess in the iliac region. The series of symptoms just enumerated continued without much change, except occasional intervals of intermission and exacerbation, until 8 P.M., Thursday, June 20th, when she became very restless and unable to sleep, moving automatically in bed; complained of pain in the right side; mind wandering; breathing with difficulty, at times suddenly arousing herself and sitting up in bed as if to get relief. Respiration rapid and short, 40 to the minute; pulse 110, smaller, and more frequent. She became chilly, and desired the window to be closed, though the night was very warm. Friction, warm fomentations of brandy and laudanum, were applied over the abdomen. Stimuli, brandy, etc., were administered internally.

7.30 A.M.—Had fallen into a lethargic sleep, face and neck becoming purple; continued in this condition, rousing unconscious at intervals until 3 P.M., when she awoke, remarking that the weather had become very cold. She asked for extra blankets. At this time the countenance had become very anxious, and the hands and feet were cold and moist. At 9 P.M. she

had a general chill, becoming icy cold; fingers and nails were blue; breath cold; pulse 160 and thready; respiration more rapid and shorter; glassy expression of eyes. 12 o'clock (midnight), asked to be straightened in bed; pulse scarcely perceptible, and impossible to be counted; respiration more feeble and shorter; surface cold and clammy. She uttered some muttering sentences, and lapsed into a state of stupor, sinking gradually; vitality ceased at 2 A.M., Saturday, the 22d June.

Post-mortem.—The following is an extract from the notes taken of the autopsy by an assistant: On opening the abdominal cavity some of the intestines were found glued together toward the lower part and to the right of the hypogastrium, so that it was difficult to separate and follow the track of the alimentary canal. The adhesions were most marked at the right iliac region, where, on examination in the iliac fossa, an abscess of considerable size was found. This communicated with the large intestine at the caput cæcum coli, and by a canal, along which the finger could be readily passed, extended behind the peritoneum and over the linea ilio-pectinea into the true pelvis. Pus was found also both before and behind the uterus, the abscess having burrowed in this direction among the pelvic cellular tissue. The origin and seat of the abscess were in the iliac fossa, and it undoubtedly had its commencement in connection with the vermiform appendix. The projecting part of this process was mostly removed by ulceration, and confounded with the disorganized tissues forming the walls and in the vicinity of the abscess. In proximity to this seat of ulceration, the débris of the foreign substance, about the size of a compressed bean, triangular in shape, and which had caused the abscess, was found lodged among infiltrated pus and discolored sphacelated cellular tissue.

The thorax when laid open was seen to be free from adhesions or other sign of antecedent disease. There was no effusion in the pericardium, and the heart was normal in size and structure; upon opening the right auricle some semi-fluid blood was found. The right ventricle was nearly filled with a tough, dense, yellow-colored deposit, which extended upward into the trunk of the pulmonary artery, past the bifurcation, into the right and left pulmonary arteries. The basis of this fibrinous deposit was entangled among the

triangular segments of the tricuspid valve and the mesh-work of the chordæ tendineæ. There was a small portion of soft coagulum resting on the yellow deposit. The left auricle contained some semi-fluid blood, and the left ventricle a soft red coagulum of small size. The tissues of the pulmonary artery and of the aorta, with the semi-lunar valves, were healthy, as were also the tricuspid and mitral valves. The lungs were sound, but dark-colored and much congested. The condition of the right side of the heart as revealed by the autopsy explains the symptoms which appeared during the last twenty-four hours, and the sudden collapse which rapidly ended in death.

In this case embolism apparently began to tell upon the system only about forty-eight hours preceding death.

The cases just cited are interesting and instructive, as they show, not by inference but by positive demonstration, that a condition of the blood exists at times in which the circulating fluid is predisposed to be easily disintegrated, the fibrinous portion separating from the other constituent elements, and forming a solid, yellow, elastic plug, which fills up and assumes the shape of the cavity or tube in which it is deposited. When the numerous constituent elements existing in the blood are considered, it is not difficult to understand that a change in the normal relative proportions of the component parts can take place, and that as a result, in a partially devitalized state, solid precipitates may form, as in the case where the fluid of the urine has become abnormal in its composition, and surcharged with certain ingredients. These fibrinous embolismic aggregations probably begin about the tricuspid valve. The blood flowing from the carotid and jugular of an animal still living, if whipped up with a small rod while falling into the basin receiving it, will separate into a fibrinous solid portion and into a remaining fluid portion composed mainly of red and white corpuscules, albumen, and salts. The blood in traversing from the right auricle into the right ventricle has to pass under the tricuspid valve and among and through the intervals or meshes of the chordæ tendineæ, which connect the columnæ carneæ of the ventricle with the margin of the valve. During the diastole and systole of the heart the tricuspid valve is in continual play, the chordæ tendineæ becoming tense and relaxed in following and regulating the action of the

valve. The blood, already in a hyperinotic condition, and thus churned and agitated in its transit onward through the auriculo-ventricular opening, begins to deposit the new formation. This progresses, with an elongated and gradual aggregation of the mass, until the cavity of the ventricle and the pulmonary artery, and, in some instances, of its primary branches, is filled with the embolismic material, thus obstructing almost the entire circulation. My own conclusion in regard to fatal embolism of the centre of the circulation is that its seat almost always is in the right ventricle and pulmonary artery or arteries, that it is of gradual formation, and that it is usually accomplished or elaborated to the extent of destroying life in from twenty-four hours to four or five days.

The first indication of embolism of the right side of the heart and pulmonary artery may be a fit of fainting, but the pathognomonic symptoms are those of general collapse: coldness of the surface, particularly of the hands and feet; small and rapid pulse; muffled and distant sound of the heart; more or less torpor; at times great distress about the chest; rapid, short, and sometimes gasping respiration. Toward the termination, the symptoms increase in gravity. There is often a belief on the part of the patient that he is getting better. The distress increases, the intelligence begins to waver, and there is muttering delirium at times. Death supervenes upon insensibility, preceded usually, a short time before dissolution, by signs of great agony. There is generally mucous râle, and signs of pulmonary congestion.

In contradistinction to those cases of embolism of the heart and pulmonary artery in which the progress toward death is rapid but not sudden, there are others in which the fatal result takes place almost instantaneously.

Case.—Among others, I select the case of Mrs. R——, æt. 23, of good constitution, who was attended by Dr. Maclennan, of this city, in her second accouchement, during the early part of July, and at whose autopsy I was present. This lady had an excellent delivery, without any complication whatever. She was having a good convalescence up to the twelfth day after confinement, and was well enough to be permitted to sit up for a short time. She was seen by her medical attendant at 1 o'clock P.M., who con-

sidered her in a favorable condition. Soon after this interview she got out of bed, dressed with a loose wrapper, and seated herself on a chair. Every thing was tranquil in the room, her aunt only being present, with whom at intervals she interchanged some pleasant passing words. At 4 P.M., most unexpectedly, she threw herself back in the chair, and after several gasping respirations, suddenly expired.

This case affords an example where death occurred almost as suddenly as if the patient had been killed by lightning. I am not aware that the cause of this diversity in the mode of dying in these cases has been satisfactorily explained. It has been already stated that, in cases of embolism of the heart and pulmonary artery, the formation of the fibrinous deposit commences about the segments and mesh-work of the tricuspid valve, and that the mass gradually aggregates and extends upward toward the tube of the pulmonary artery. The circulation is not abruptly obstructed, and the stream of the blood is only gradually diminished, the vitality ceasing by degrees, accompanied by the distressing symptoms already detailed.

In the cases of sudden death the right ventriculo-arterial opening becomes in a striking manner the gateway of life. The fibrinous deposit in such instances may form more rapidly, but the source of immediate death is the sudden detachment of a portion or of the entire deposit from its original base or attachment around the segments and chordæ of the tricuspid valve. During the systole of the heart this fibrinous mass when thrown off is hurried along in the current of the circulation through the ventricle up to the opening of the pulmonary artery, and immediately blocks up the orifice of that vessel after the manner of the valve of a pump. The entire pulmonic circulation being thus in a moment intercepted, unconsciousness and death follow on the instant. It may be suggested that the embolism may begin in the pulmonary artery around the semi-lunar valves. It is not likely that a deposit beginning at this part would accumulate so rapidly as to produce instantaneous death, and, moreover, the *post-mortem* facts do not support this supposition.

Autopsy.—In the case of Mrs. R——, before opening the body, the source of the sudden death was distinctly understood and expressed. Upon

laying the chest open, by removal of the sternum, the organs appeared healthy. The pericardium was opened, and contained a small portion of serous fluid. The heart was of natural size, and while kept in situ a free incision was made through the wall of the right ventricle. A quantity of fluid blood flowed freely through the incision, coming partly from the right auricle and venæ cavæ. Some fragments of detached yellow fibrinous deposit passed along with the blood. On sponging the right ventricle and carefully freeing it from blood, at the upper part of the ventricle a soft, yellow, fibrinous plug as large as a small walnut, irregularly flattened, was found completely blocking the orifice of the pulmonary artery. This, when drawn from its position, revealed a kind of vermiform prolongation that extended along the tube of the artery for about three-quarters of an inch. The tricuspid valve was normal; among the chordæ tendineæ and along the margin of the valve irregular portions of soft, tough, yellow, fibrinous deposit remained entangled. The left ventricle was next opened in the same way. There was no clot or blood in this cavity, or in the left auricle, and the mitral valve and the surface of the internal walls of both cavities were perfectly healthy. The aorta and pulmonary artery were then slit open, and the valves and vessels found perfectly normal. There was a portion of fatty material upon the external surface of the heart, but too small to be of importance. The rest of the body was healthy.

The conditions which favor this peculiar pathological state of the blood are prolonged mental emotion, and whatever produces great perturbation of the system, as often takes place in the puerperal state, in hemorrhages, in aggravated disease, in shock from intense mental agitation, or from severe traumatic lesion.*

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* I have no doubt that a psychological embolism of the heart and pulmonary artery at times takes place; that is, by prolonged mental emotion and agitation a condition of the blood is brought about that favors its disintegration, and that the disintegration is more or less rapidly effected upon the occurrence of some sudden or unexpected intercurrent additional cause.

The case of William M. Tweed, at one time the political dictator of this State, is an example of this kind. He had suffered much from imprisonment and from mental agitation for several years. At length he was induced to believe that he would be liberated under certain conditions, which he is said to have fulfilled. I was requested to see him on Monday, April 8th. His physical condition was greatly changed for the worse, and he complained of *malaise* and general indisposition. He was elated at the prospect of soon leaving his place of confinement. He

At times a condition of the system arises after injuries which may be called *secondary* collapse, indicative of cerebral anæmia and interrupted innervation, and of a want of capability in the central ganglia to supply the amount of nervous influence requisite to sustain the functions of life. In such instances the vitality seems to rally, and signs of restoration to manifest themselves, but the effort is transitory, and a new series of symptoms makes its appearance more unfavorable than that which followed immediately upon the shock of the injury. There is now collapse, with evidences of excitement in the system, as if of an extreme attempt to arouse and bring to the rescue the last reserve of the rapidly failing resources. This condition is allied to *nervous delirium*, but its progress is characterized by evidences of deeper prostration, and offers less hope of a favorable termination. *Nervous delirium* is generally the result of injury to a system already enfeebled and broken down by irregular courses of life, while secondary collapse, as at present considered, may occur in any condition of the system, and is the product of some single great injury, or, more generally, of one of a complex character, involving several organs, and indicating the extreme exhaustion of the ganglionic centres by which the morbid impressions of the injury or

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dressed and was about his rooms daily, and showed no signs of incurable disease. He became better on Monday and Tuesday by gentle medication, and on Tuesday afternoon I left him still improving. News of failure of the efforts to secure his release were confirmed, and reached him. The officers of the law, as he supposed, had broken faith toward him, and put an end to the hopes he had entertained of soon regaining freedom. Early on Wednesday morning I received a telegram, written by himself, that he had passed a bad night, although then better, "all but his heart, where there was great distress." I made an early visit, 8 A.M., and found him very ill. His features were pinched, the countenance leaden and dark purple, the pulse rapid and feeble, respiration short and frequent, hands and feet cold. The mind was clear; he conversed and begged to be relieved from his great distress; the sounds of the heart were feeble, without abnormal *bruit*. He continued in this condition during the day, obtaining some relief from medication; great restlessness, complaining much of thirst. During the night of Thursday he frequently got out of bed and sat up on a chair as if seeking relief. The symptoms were relieved only by anodynes and stimuli.

Friday morning, 10 A.M.—The mind, although generally clear, wandered at times. He was very restless; the coldness of the surface and of the hands and feet continued; forehead cold and moist; pulse 150; respiration 48 in the minute and short; asking continually for drink.

3 P.M.—The symptoms all aggravated; intelligence waning; stupor; pulse thready and not easily counted; respiration more rapid and shorter; cold and clammy sweat over the surface; subsultus tendinum; sinking rapidly. At 4 P.M. he became comatose, and died without a struggle.

The family objected to have an autopsy, but in this case the diagnostic signs of embolism of the heart and pulmonary artery were certainly present.

injuries were primarily received and transmitted. In such instances the symptoms of prostration most evident at first, although apparently growing more favorable, are succeeded by another series of morbid nervous sympathies. The progress and termination of this class of lesions can be better studied in cases of severe injuries of the head when associated and complicated with lesion of other organs remotely placed relatively to the great cerebral ganglia. Thus, in a railroad accident, there may be injury of the head of such gravity as to produce collapse with coma, and a limb may have been crushed at the same time, which of itself would have been sufficient to produce collapse. It is not difficult to comprehend that in this latter case the cerebral symptoms may remit, and that the patient, at first insensible and laboring under the collapse from the concussion, may, to a certain extent, be restored to consciousness and to apparent improvement. But a limb having been crushed besides, and the morbid influence from the seat of this superadded injury being still at work, it is transmitted to the central ganglia so as to prolong the original effects of the shock, or to produce a new or secondary phase of prostration and collapse, followed by a new class of symptoms. Thus a chain of morbid phenomena may ensue in other instances of extensive injury to any set of sentient tissues or to any group of organs. The following case will partly explain the varied play of morbid sympathies that takes place when an injury of a diversified or multiform character has been received.

Case.—F—— M——, æt. 50, of robust constitution and sanguineous temperament, while driving along the street, one Monday evening last September, in a light wagon, at a rapid pace, was run into by another vehicle and upset. He was thrown violently upon the pavement, and struck on the curb-stone with the left side and back of the head. He also struck on the left shoulder, and in his heavy fall fractured the clavicle and four superior ribs near their attachment to the spinal column, severely injuring at the same time the upper lobe of the lung of that side. There was also some injury or concussion of the medulla spinalis. He was picked up insensible, and immediately carried to his home, which happened to be within a short distance. He remained comatose during the night, breathing stertorously,

with a slow, compressible pulse, ranging between 40 and 50 beats to the minute, cold and moist surface, and other signs of collapse. Toward morning, at 3 o'clock, he regained sensibility and consciousness so far as to be able to ask for water, and at times to answer questions rationally.

Tuesday, 7 A.M.—Pulse 70; respiration 16 and irregular; the countenance suffused; speech distinct at times, at others only a semiconscious muttering; complained of great pain in the upper part of the chest and at the shoulder. In the course of the day the stupor of the concussion kept decreasing, the skin became dry, and rose above the normal temperature. The pulse was rapid, bounding, but feeble; the respiration at times hurried and irregular. There was frequent vomiting. At 3 P.M. he had a convulsion which lasted for about five minutes. After it, the pulse rose to 110. Convulsions continued to occur, at intervals of from three to six hours, up to midnight, with prevailing restlessness and uneasy moving in the bed. All the symptoms of excitement were undiminished, and there was absolute sleeplessness.

Wednesday.—I saw him at 5 A.M., having been sent for to meet the attending physician, Dr. Molony, who had been giving sedulous and skilful attention to the patient. I found him coming slowly out of a convulsion, slightly delirious, with tremors and twitchings of the muscles. I saw him again at 10 A.M. His skin was hot, the pulse rapid, the respiration hurried and imperfect. He was conscious, but sometimes incoherent. He did not complain of pain in the head, but of great distress about the thorax and shoulder. Where the head had struck the pavement there was a contused wound of the scalp about an inch in length, and I advised that this be enlarged in order to be assured that there was no fracture of the skull with depression of bone at this point. There was no fracture. For the rest of the day the symptoms remained unchanged. He slept a little during the night, but was frequently roused, apparently by the pain about the chest. He suffered from great thirst, and in his speech was often incoherent. There was much flatulence with tympanitis.

Thursday morning.—It was becoming evident that the amount of injury was too great to allow one to expect a remission of the symptoms from any treatment. All the manifestations of prostration with excitement grew more

aggravated. The tongue, when partially protruded for examination, was coated and tremulous, the muscular twitching and agitation, the wanderings and delirium, were more marked. The pulse rose to 140, with irregular, hurried, and imperfect respiration, about 40 to the minute. The convulsions continued at intervals of three to four hours. The period of excitement seemed gradually merging into one of extreme prostration and collapse. A cold and clammy sweat gradually broke out upon the surface, the countenance grew paler and more distressed, the pulse reached 160, small, irregular, and fluttering. The twitchings of the muscles and subsultus tendinum became more acute, the incoherency increased, the eyes became glazed, and with a final convulsion, ending in coma, death supervened.

The treatment consisted in the administration of suitable cordials during the first stage of collapse, with warmth and friction to the extremities; during the stage of excitement and prostration, small doses of tincture of aconite to reduce the action of the heart, and Champagne to sustain the system and allay the great thirst; toward the last stage, when the collapse became extreme, brandy with carbonate of ammonia was added; turpentine injections were twice administered, to revulse from the brain and to relieve flatulency. Chloroform was administered at times during the convulsions.

The symptoms related in the preceding case are typical of those instances of severe injury that, as they progress, merge into a condition that is marked by excitement associated with great prostration. It appears difficult to reconcile the presence at the same time of such opposite phases of the system as excitement coupled with prostration. The increased temperature of the surface and of the internal parts of the body would not seem to indicate an exhaustion of nervous influence, and the more frequent action of the pulse and of the heart would at first favor the supposition of greater propelling force in the apparatus of the circulation; but upon attentive examination it will be found that the action of the heart is feeble, although the number of its pulsations is greater. English writers have bestowed much study and consideration upon this peculiar state of the system, which frequently supervenes upon shock and collapse. John Hunter called it *irritability;* and the phrase *prostration with excitement*, first used by Mr. Travers,

has been generally adopted by British surgeons. The explanation of the phenomena given by recent authorities, and generally accepted, is found in the subjoined extract, but it is too vague to be satisfactory:

"Now these symptoms of extreme excitement leading so rapidly to fatal exhaustion are unquestionably evidence of excessive action and deficient power. . . . There is no more important subject for inquiry than the relation of action to power in the living body. In the condition of health the balance is uniformly maintained, or at least the supply is equal to the demand. But if from any cause the power of an organ, on the function of which life is immediately dependent, be much impaired, this difficulty arises: its functions must still be discharged to an extent at least sufficient for the purposes of life, and therefore deficiency of power may need to be redeemed by increase of action. But action involves exhaustion, and repose is needed for repair. The greater the effort, therefore, the greater the exhaustion. But again, decreasing power must be met by increasing action. Thus cause and effect react each on the other; the relation between power and action becomes more and more reversed, until at length, the supply diminishing, and the demand for action and repose alike augmenting, the crisis, with rapidly increasing pace, is hurried on.

"No organ illustrates this so strikingly as the heart, and under no circumstances better than in the present case. An impression is produced upon the heart, whereby its power is for some time impaired. But, that life may last, it must still to a certain extent circulate the blood. If it be too feeble to accomplish this necessary task at its ordinary rate of action, its frequency must be increased. But action is succeeded by corresponding exhaustion; and so, if the supply prove unequal to the demand, follows prostration with excitement, deficient power and excessive action, the pulse increasing in frequency as it fails in force."*

This explanation is hypothetical, and does not convey a distinct sense of the phenomena in question.

In all severe injuries followed by collapse a deficient supply of oxygen to the tissues and organs necessarily follows as a sequel to the general per-

* Holmes's *System of Surgery;* Travers, *On Constitutional Irritation.*

turbation and exhaustion of the nervous centres. This want of supply creates an impression throughout the system, which, by reflex action, is carried to the respective organs whose function it is to furnish the necessary aid. The heart and lungs consequently respond, and act for a time with increased but faltering activity. We thus have one cause for the frequency both of the pulse and of the respiration. Another cause of the frequency and irregularity of the pulse arises from the disturbance of the normal balance of functions between the organic and the pneumogastric nerves which compose the cardiac nervous apparatus, and which receive the impression transmitted from the seat of injury. The rhythm and the co-ordinate action of the heart are thus to a certain degree modified and altered.

The question now arises, how the increased heat of the surface and throughout the body, together with the signs of general morbid excitement of the system, can be accounted for. My own conclusion is that during collapse the normal tension of the arterioles is greatly diminished, and that the general circulation having thereby become more rapid and free in cases where there is prostration with excitement, there is an increased flow of blood into the relaxed and dilated systemic capillaries. This is accompanied by an abnormal and excessive evolution of heat, consequent upon and owing to the accelerated chemical changes attending the molecular metamorphoses of the tissues and organs which in health would be progressing normally in the decay and the repair of the body.

"Prostration with excitement" has been called imperfect reaction. But the symptoms from the beginning of the changes following upon ordinary collapse being indicative of increasing prostration, and reaction implying an improvement of the existing morbid state, the term reaction is incorrect.

Secondary shock may also arise from mismanagement in the primary treatment of injuries, such as occurs from abrupt removal of the wounded on the battle-field to a great distance, or in cities by unnecessary change of locality. In civil practice, cases like the following are met with: J—— F——, æt. 68, in attempting to get upon the platform of a street car while it was in rapid motion, missed his footing, and was thrown with violence upon the pavement, breaking the right femur high up toward the trochan-

ters. He was picked up insensible and carried into a store, and from there was removed to one of the temporary municipal hospitals near the City Hall Park. He was placed properly in bed, and by the aid of cordials and a temporary adjustment of the fracture he was made comparatively comfortable. There was a favorable reaction on the following morning. About mid-day, for some reason, he was transferred to one of the larger hospitals in the upper part of the city, some four miles off, over badly paved streets. This caused a repetition, as it were, of the original shock, and was followed by renewed symptoms of collapse. He continued to sink gradually, and died about noon the next day.

If this patient had been allowed to remain where he was doing comparatively well, and had not been transferred under such unfavorable circumstances, it is probable that he would have recovered.

The battle of Spottsylvania took place on the 18th May, 1864. Many men were brought to the medical head-quarters of the different corps badly wounded by exploded shells, Minie-balls, and cannon-shot. Some of the most severe lesions were accompanied by splintered and comminuted fractures of the large bones of the superior and inferior extremities. They were placed in shelter-tents and received a certain amount of attention, but, for the moment, there was a want of such retentive apparatus as is required in the treatment of fractures. Still, by the use of cordials, quiet, and anodynes, many of the injured began to rally from the collapse. On the night of the 20th, an order was issued from head-quarters for an advance of the army in the direction of North Anna, the wounded to be transported beyond the reach of Confederate skirmishers to Fredericksburg, where a number of military hospitals had been organized, as the basis of the ambulance corps. Fredericksburg is distant about twenty miles from the battle-field, and the roads at that season were in a very bad condition, almost impassable in many places, and at others made up of trees laid crosswise over the morasses, forming the common corduroy road of the South. In this instance a military necessity, in the opinion of the general-in-chief, required that the wounded should not be exposed to fall into the hands of the enemy, and removal became imperative. This necessary alternative was an unfortunate one for the severely

injured, such as those who had the femur or other large bones shattered by a shell or ball; for besides the dreadful suffering experienced from the rolling and jolting of the wagons of the ambulance over the rough roads, many of such cases, and cases of injuries to the splanchnic cavities, had a renewal of collapse, and succumbed to a repetition of the first shock, occasioned by the inevitable jolting of their transportation.*

After capital surgical operations the balance between life and death is sometimes decided against the patient by mistakes or negligence in the after-treatment, causing development of secondary shock.

Case.—About six weeks ago I was called to see Mrs. B——, an elderly lady, æt. 78, of wiry constitution, and, for her time of life, possessing a fair condition of health. She was suffering from irreducible strangulated femoral hernia, with the usual concomitant symptoms present to such a degree as to render an operation necessary. This was carefully performed, without anæsthetic, by the patient's desire, and without complication, except the presence of extensive adhesions between the intestine and the inner surface of the hernial sac. The bowel was returned entirely liberated, and although of claret-color, was free from any odor of incipient gangrene. The collapse from the operation was not excessive, and a comfortable reaction was established about twelve hours after the operation. On the afternoon of the following day, by the administration of a half-ounce dose of castor-oil, the peristaltic action of the intestinal canal was established, followed by a healthy evacuation. On the third day the patient was so far free from any unpleasant symptoms that on my visit her brother, who in early life had practiced surgery, met me at the door very much gratified, saying that his sister had passed the ordeal, and he considered her out of danger. Quiet was enjoined, and light nourishment with wine and water ordered. On the afternoon of the same day the patient took a fancy that she needed an enema, and insisted upon the nurse administering one at once. This acted with severity, and the effect proved to be too much at her age. She was thrown into a secondary collapse, from which she never rallied, but continued to sink gradually,

* Instances of this kind will necessarily occur during a protracted and active campaign. I mention the battle of Spottsylvania, as I happened to be present.

and on the afternoon of the fifth day after the operation she expired from exhaustion.

Indirect Effects of Shock.—Certain conditions of the system, marked by adynamia or asthenia and a general failing of the vitality, occur sometimes after injuries of gravity, and are followed by indirect pathological results not always in correlation with the character or extent of the shock received, but which ultimately terminate in death. For example: a person driving in an open wagon, with the seat insecurely fastened, by a sudden start of the horse is thrown out backward, striking the ground violently on the back, fracturing the ribs, injuring the lungs, and showing signs of concussion of the medulla spinalis, and, for the time, of general collapse. The patient may recover from the immediate effects of the shock, but vitality languishes, the general health becomes irretrievably impaired, and death ensues sooner or later, as occurred in the case of an eminent actor that came under my observation several years ago.

The remote or ulterior effects of shock upon the system after severe injuries is a subject of much interest, and of sufficient importance to claim special consideration, apart from the primary treatment of injuries.

The deleterious effects upon the blood from sudden and violent impressions made upon the nervous system, whether from psychological or physical causes, or from the simultaneous combination of both, are often the source of dangerous and fatal complications.* The devitalization of the blood is a rapid sequent in instances of injury resulting from lightning. In high states of emotion the secretions are often abruptly changed, so that an offensive odor is suddenly emitted from the cutaneous or respiratory surfaces; and it is said that the bland and nutritious character of the mother's milk will be changed at times under intense mental agitation into a poisonous fluid, fatal in its effects upon the child.

From this it is evident that the blood, which normally is the natural source of life, as well as of nutrition and secretion, may become converted, from the changes which take place in its structure and vital properties, as

* In the case of M—— B——, page 161, the patient had suffered greatly from mental agitation and depression for over two years previous to her last illness. The temperature, when given, is from the axilla or mouth.

well as in its chemical composition, into a fluid of a dangerously toxic character, and unfit to sustain the functions of life. When the impression of the shock is of less intensity, the devitalization may not be so complete and destructive, yet the change may be so great as to lead to inflammatory action of an adynamic type, associated with perverted molecular nutrition and degeneration of the tissues. Under the head of *complicated shock* it has been stated that pyæmia was to be considered as one of the formidable complications. The blood becomes so decomposed that an ichorrhæmic form of pyæmia is produced by the generation of a noxious fluid in the blood itself. A state of the circulating fluid thus in a degree idiopathically generated, although from a remote traumatic origin, induces universal disturbance of all the organs and functions, accompanied at times by traumatic fever of a typhoid character, by nervous delirium, by purulent deposits, by diffused inflammation in the great intermuscular planes of areolar tissue with purulent infiltration, by inflammation of the mucous membrane with diarrhœa, and of the serous membrane with effusion.

It has been stated that one of the results of shock and collapse, especially in the protracted form, is a condition of the blood which favors the separation of its constituent elements, and leads to the formation of fibrinous deposit in the right ventricle of the heart and in the tubes of the pulmonary arteries. This condition of the blood would, under similar circumstances, induce the formation and implantation of small, isolated, irregular, fibrinous products upon the mitral valve, either toward the base near the auriculo-ventricular opening, or toward the margin of the valve. One or more of these warty-shaped deposits may become detached or dislodged, float along the left ventricle in the direction of the arterial current toward the aorta, and, passing onward, form a veritable embolism in any of the tissues or organs, thus blocking or interrupting the circulation at some point where the calibre of the vessel is insufficient to permit of the transit. In this manner various intercurrent diseases, originally depending upon shock and collapse, may be developed, and give rise to other complications, such as the embolismic form of pyæmia.

Embolismic granules or deposits of fibrin may occur in any part of the

circulatory system, but the mitral and aortic valves generally are the localities or sites where they are at first implanted, and from which they are dislodged and thrown off to pass along with the current of the circulation.* The right side of the heart is most liable to be the seat of large, yellow, fibrinous deposits, the blood being venous, and more readily separated into its elemental parts by the anatomical arrangement of the tricuspid valve than that on the left side, which, being arterial, and less agitated or lashed by the mitral valve, is not so subject to disintegration.† When clot is found on the left side of the heart, as in case of thickening of the mitral valve with contraction of the left auriculo-ventricular opening, the coagulum filling the left auricle retains in a *great measure* the red character of clot composed of all the constituents of the blood.

Under the microscope, the deposits heretofore described as lodged in the right ventricle and pulmonary arteries presented the histological characteristics of fibrin. When formed rapidly they are of a deep yellow or tawny color, retaining still some of the red corpuscles of the blood; when occurring in protracted asthenic disease, forming slowly, and freed from coloring matter, they assume a light chrome-yellow tinge, resembling in this respect the appearance of adipose sarcoma recently removed.

Physiological correlative Conditions which modify the Effects of Shock.—Various circumstances modify the effects of shock upon the system, one of which—the *temperament* of the individual receiving a severe injury—

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* The type of endocarditis which is often associated with rheumatic inflammation is at times the source of millet-seed-shaped vegetations springing from, and implanted in a pedunculated form on, the mitral valve. One or more of these may be detached from the mitral valve, pass into the arterial circulation, and become lodged in one of the smaller arteries. If stopped in the middle cerebral artery, as sometimes happens where it courses along the fissure of Sylvius, embolism of that artery will be the result, inducing ramollissement of the contiguous parts of the brain, and consequent rupture of the vessels involved, followed by hemorrhagic effusion extending to the base of the brain and over the cerebral hemispheres, general paralysis, and speedy death, a case of which I have lately seen.

† The mitral is supplied with fewer chordæ tendineæ than the Eustachian valve; also, the systemic side of the heart, on account of embolismic obstruction of the pulmonary artery, receives less blood.

The left auricle is liable to be filled or gorged with red clot where there is coarctation of the left auriculo-ventricular ostium with thickening of the mitral valve as far as its base. In such cases the left ventricle will be found nearly empty, without fibrinous deposit, partly on account of the impeded play or action of the mitral valve, and partly from the small quantity of blood usually passing through the ventricle.

should be particularly taken into consideration. The word was vaguely used by the ancients, who supposed that the peculiarities of the natural organization depended upon the admixture and relative preponderance of four humors of the body then admitted by them—the blood, the lymph, the bile, and the atrabilis or black bile. It was believed from observation that certain predisposing and regulating influences presided over the actions of the body in health and in disease, and modern authors recognize a theory of similar purport, based, however, upon the more precise facts of general anatomy and physiology. The term may be said to signify the general result or manifestation, for the organism, of the predominance of one organ or of one system over others in the same individual. The doctrine of the temperaments has been modified, since it is understood that it is to the special functions of the encephalon that the inclinations or affections, the passions, the intellectual faculties, and the moral qualities are to be mainly attributed, and not altogether to the constitutional peculiarities or structure of the organization. The temperaments are now grouped under four heads—the sanguineous, the lymphatic or phlegmatic, the bilious or choleric, and the nervous. These are seldom strictly distinct or pure, but run into different combinations, such as the nervo-bilious, the nervo-lymphatic, and the nervo-sanguineous; or the preponderating indication may be placed first, as the sanguineo-nervous, the sanguineo-lymphatic, etc., in order to indicate the relative activity and excess of the ruling element. In fact, the combinations and peculiarities of constitution in regard to the various relative proportions of the preponderating influences in the organism are exceedingly complex, and can be grasped and weighed accurately as to their import in disease or in health only by experience. The consideration of the temperaments thus viewed becomes a study of the physiological anatomy and histology of the organism, by which each temperament is made to designate a special condition or type of the constitution.

The term sanguineous temperament is applied to individuals of florid complexion, whose constitution is marked by a greater natural development of the vascular system, in whom the blood-vessels are larger, more filled with blood, and who also present a predisposition to inflammatory affections.

Where the organism of the individual exhibits a generally spare development of adipose tissue, and where there is an evident display of activity, and tendency to unusual impressionability and irritability of the nervous system at the centres and at the periphery, the term nervous temperament is used, and in such individuals a predisposition to nervous disorders is known to be present. Those who have light hair, pallid complexions, thin skin, a considerable development of the adipo-cellular tissue, thick lips, apparently cold-blooded, with an inactive expression, belong to the lymphatic temperament, and are predisposed to derangements of the lymphatic system, to scrofula, to tuberculosis, and other strumous diseases. The bilious temperament is attributed to those who possess a dark complexion, dark hair and eyes, a stolid countenance and sluggish circulation, and who are liable in an unusual degree to derangements of the chylopoëtic viscera. The term choleric or melancholic temperament, which has been ascribed to the influence of the black bile, is now only used in a figurative sense. If the hypothesis of the ancients, however, be erroneous as to the cause, the mental condition which gave origin to the name is a reality, and dependent on a sufficiently valid cause, for the psychological condition known as melancholia is often the result of the influence of the deranged hepatic system reacting upon the brain through the medium of the grand sympathetic.

Such, in brief, are the main characteristics of the distinct types of the several temperaments as now recognized; the various shades of combination are too complex to be here enumerated, and are left to the judgment and discrimination of the observer. By the study of the temperaments useful knowledge can be gained in regard to the particular constitution of each individual, that may, in cases of shock followed by collapse, afford general information in forming a prognosis and in directing the treatment.

The *diatheses* are allied to the temperaments, modify the organism, and tend to influence the effect of impressions made upon the system. The several diatheses are divided into distinct heads; and although their influence may not always be perceptible, the peculiarities of the constitution represented by them should not be overlooked. According to some authorities the definition of the term has been confounded with the word temperament;



PRIMARY TREATMENT OF INJURIES

FIELD AMBULANCE SERVICE – BEARING WOUNDED TO HOSPITAL

Scene behind a portion of the line of battle at Gaines' Mill, Va. June 27th 1862.



but while the latter does not imply the presence of any disease, the word diathesis is usually intended to convey the idea of an abnormal condition, in other words, that all the tissues or fluids of the body, or some certain ones among them, are tainted with an abnormal pathological alteration or change in their condition. The diatheses are more latent than the temperaments, and yet they become developed into morbid activity under the influence of a new or sudden pathological cause, and thus produce a modified phase in disease, whether of internal or external origin. A person laboring under any of the several diatheses, such as the syphilitic, the scrofulous, the cancerous, or the scorbutic, is not able to withstand the effects of a traumatic lesion as well as one free from taint; and if the cachexia be very marked or pronounced, reaction after a severe injury is on this account modified and retarded, or prevented altogether.

The *hemorrhagic* diathesis would certainly make a serious complication in cases of shock from injury, in which a solution of continuity occurred in the form of an incised or contused wound. For example, a boy after recovery from ophthalmia was sent to the Refuge Department of the State Hospital. While playing with his companions in the grounds, he tripped suddenly and fell, striking the forehead on a sharp stone. He received an incised wound about two inches in extent along the left side of the forehead, ten lines above the superciliary arch. He was stunned, and showed signs of collapse. He was removed into one of the hospital wards, and the house assistants found it impossible to stop the bleeding. The hemorrhage was kept in abeyance only by compresses and direct pressure maintained by the hand for some hours, until I saw the patient. Several styptics had been tried, such as the application of ice, solution of perchloride of iron, etc., but without avail, and the boy was gradually sinking from loss of blood. In the emergency I called for some long Carlsbad pins, and passed them deeply through the wound, inserting the points half an inch from the margin, and bringing them out at a place equidistant from the edge on the opposite side of the cut, and placing each pin about half an inch apart along the course of the incision. This done, a figure of 8 ligature was passed around the first pin, joining it to the next by crossing the same ligature over the lips of the wound to

reach the second pin, and so on until the wound was completely covered and blocked. This proceeding seemed to arrest the bleeding for the time. A moist compress was laid over the wound, and a roller bandage applied so as still farther to keep up the pressure. The boy was now placed in bed, and beef tea and other light nourishment given him at short intervals, with brandy and ammonia. Gallic acid was administered internally. There was a slight improvement in his condition, but the symptoms of collapse continued. The bleeding had now lasted for some ten hours, as often as the pressure had been removed from nine in the morning until seven in the evening. He was restless during the night, and slept but little, tossing uneasily. In the morning the pain in the head became so severe that I was sent for, and saw him about ten o'clock. The bandages were moist with blood, and bulged outward opposite the wound. It was evident that the removal of the entire dressing was required. When this was done, a large soft fluctuating tumor was found under the pins, diffused among the tissues and layers of the scalp, and projecting forward. In shape and size it resembled the half of an orange. Upon removal of the pins a quantity of fluid blood gushed forth, leaving some soft dark-colored clots at the bottom of the wound. The bleeding still continued *en nappe* from the general surface. The clots were speedily wiped away, the surface of the wound cleaned, and a sheet of compressed sponge wetted with a solution of the perchloride of iron laid firmly in the wound, so as to be in contact with the entire surface. A compress, in which was enveloped a layer of sheet-lead, was then laid over the sponge, and a firm roller bandage placed around the head. The patient was kept in the recumbent position, in a cool temperature. Nourishment and brandy were given at intervals, and acetate of lead and opium administered internally. Reaction could not be brought about, sickness at stomach and vomiting supervened, and it became apparent that vitality could not be sustained unless the hemorrhage could be checked. This fortunately was effected. Soon after the last dressing the patient became more comfortable, had some quiet sleep, and the sickness of the stomach subsided. There was very slight oozing through the bandage, which, becoming dry, indicated that the bleeding was subsiding. The patient was sedulously watched, and plied with small and

often-repeated doses of brandy, ammonia, and juice of beef. Warmth was kept up on the surface by blankets, and heated bricks to the feet, and in the course of some hours feeble signs of reaction began to manifest themselves. The roller bandage was allowed to remain for twelve hours, and then only partially removed, leaving that portion which had become dry and adherent over the wound unmolested. This was replaced later by one applied more loosely around the head. The bandage was now removed daily, without disturbing either the sponge or adherent portion of the original bandage, and the parts cleaned of the grumous bloody serum which continued to ooze from the wound. On the fourth day the sponge and first dressing had become loosened from suppuration. This became detached on the fifth day, leaving the wound in a granulating condition. By the use of strips of adhesive plaster, so as to bring the edges of the wound together, and slightly stimulating washes, the healing process went on gradually, and in a month the boy was discharged cured. It is very evident that if this patient had not received from the first the most unremitting care and attention, he must have succumbed to the shock and collapse rendered persistent by the hemorrhagic diathesis, and the consequent obstinacy of the bleeding.

Among the various systemic peculiarities enumerated, the nervous temperament exercises the greatest influence. Under ordinary circumstances some men are exceedingly mercurial and impressible, and are so constituted as to be thrown into a state of perturbation by the odor of certain flowers, or the sight of some familiar animal, such as a cat; and in other instances the sight of blood trickling from a wound, however trivial, will produce syncope. Vivid and prolonged emotion in such cases will induce a state of chronic excitability resembling the hysteria of women, rendering them morbidly impressionable to the most indifferent causes, and consequently more susceptible to the immediate effects of severe lesions. Where this psychical impressibility to outward causes exists, severe physical pain originating from external injury will also affect the nervous system more acutely, and derange the molecular disposition or relations of the nervous cells to a greater degree, than in those of a torpid and lymphatic temperament. In cases of railway accidents and gunshot wounds, an indefinable dread or panic takes posses-

sion of the so-called nervous persons, which tends to modify and maintain the effects of shock following severe injuries to a greater extent than in those of phlegmatic natures. It may also be observed that the mental condition of such persons at the time when a severe lesion is received will influence the effect of the shock. The aphorism of Celsus, *dolor medicina doloris*, seems to be exemplified in some cases by the temporary or partial suspension, and in the less intense manifestation, of the more grave immediate effects of shock under the influence of strong mental excitement, or the depressing agency of a great pre-existing emotion. Such immunity, however, is likely to be transient and deceptive; the influence of the latest lesion is only deferred, and will before long become revealed. In fact, the grave effects of the lesion thus temporarily arrested or averted may thereafter become more intensely developed by the consequent reactionary mental exhaustion naturally resulting, and superadded to the effects of the original injury.

Influence of Sex upon Shock.—During certain periods of existence the reproductive system is quiescent, and does not exercise any particular influence over the general economy; the advent of puberty, however, changes the girl into the woman, the psychical elements of character are developed into greater activity, and the nervous apparatus becomes more susceptible to external impressions. Apart from the influence of this new series of sympathies, the nervous system of the female under similar circumstances is not more impressible or sentient to impressions resulting from external lesions than that of the adult male. During the early part of my pupilage with Professor Valentine Mott, at a period of his career when he was in active practice, and performing daily important operations, prior to the general introduction of anæsthetic agents, he was often in the habit of calling the attention of his assistants to the greater endurance of women over the other sex during the ordeal of severe suffering under the knife. From my own observation I am led to the conclusion that, independent of the physiological and pathological sympathies connected with and radiated from the uterine system, the female nervous organization is less sentient to the influence of external agencies than that of the male. This may be attributed to the smaller dimensions of the nervous apparatus in the female, and to

the consequent diminished capacity of the afferent nervous cords and their more feeble effect upon the ganglionic centres, which relatively are also of a smaller size. The cerebral mass ordinarily is greater in the full-grown male fœtus than in the female, as is learned from the statistical fact that the majority of difficult labors occur with male children, owing to the larger measurements of the head. It must not be overlooked that the education and early training of the female child inculcate the suppression of outward manifestation of the feelings and emotions, and that great suffering is often endured by them without complaint. The constitutional commotion which accompanies the *molimen mensium* of commencing puberty, and the perturbation which the system undergoes previous to and during the menstrual period, unfit the system to tolerate or resist at such a time the influence of external injuries as well as when the organism is in a more equally balanced physiological condition. During the whole period of the evolution of the ovum in the uterus the female system is unfavorably placed to bear the additional effects of intercurrent medical diseases or of external injuries. In cases of severity both mother and fœtus are likely to be destroyed, as in variola; while in accidents, such as severe burns or railway injuries, premature labor is almost a certain result, and in many instances both mother and ovum perish. On this account, when surgical operations on the female are required, the uterine condition should always be consulted, and if it be unfavorable, the operation should be deferred until a more fitting time, unless the exigency of the occasion is so imperative as to require it to be done at once.

Influence of Age upon Shock.—It is often stated in works of operative surgery that injuries received by the very young and the aged are not supported as well as those received by persons in the middle periods of life. This general statement conveys the supposition that the child in its early infancy possesses less vitality and is endowed with a more acute and impressible nervous system than the adult, and is consequently more liable to be overwhelmed by the effects of severe external agencies. Age certainly modifies the physiological condition of the individual, and exercises an important influence upon the pathological processes which occur in medical and surgical operations. Apart from the abrupt and severe effects of external

injuries, each period of life presents conditions that predispose to particular maladies. In infancy, the acute diseases of the head are more frequent; in youth, those of the chest predominate; in ripe age, those of the abdomen; while in old age the chronic affections of the head and those of the hypogastrium prevail. Physiologists variously divide the different epochs of existence that the organization passes through during the period of time which extends from birth until the natural cessation of life. Regarding the duration of infancy as limited to seven years, and taking septennial periodicity as a guiding rule, the epochs of life are divided by some into ten, by others into twelve or fifteen periods; others, disposed to attribute an equal duration to all the ages of life, divide existence, not after a fixed term based upon the length of embryonic life or of infancy, but after conventional numbers, and maintain the equal length of each age while varying the number of the periods of life. Daignan reckons fifteen ages of seven years each; Linnæus enumerates twelve; Mende admits six, and Varron proposes five of fifteen years; Philites four of eighteen years; Pythagoras four of twenty years; Schmidt three of twenty-five; and Virey three of thirty years, the last-mentioned starting upon the principle that all that is finite should be divided into a commencement, a middle, and an end.* These periods are to a certain degree artificial, and arbitrarily laid down, and do not correspond with the peculiar phenomena that are manifested during the several epochs of life. The division of life into youth, maturity, and old age is sufficiently precise for general consideration; but when viewed in relation to pathological conditions, it is not broad enough in detail. The changes and peculiarities which belong to each, and which are characteristic, do not occur abruptly or with precision. For the better study of disease the farther subdivision is required of each age into two, from which results the division of the ages into the period of infancy and of youth, of adolescence and maturity, of old age and decrepitude. The question as to the greater or less endurance of the system at particular epochs must be answered by the consideration of the stages of development of the nervous system and of the various organs and functions during the several periods of intra-uterine and extra-uterine life.

* Vide Longet, *Traité de Physiologie.* Paris.

The ultimate sources of shock are sentiency, or the susceptibility to receive impressions, and an organism so constituted as to transmit and, at times, to reflect them. The effects of shock will be more or less intensely perceived or manifested by the individual according to the perfection of the organization and its susceptibility to be impressed. The less perfect the development, the less intense will be the impressibility. The relative tolerance of shock depends on the greater or less capacity of the system to receive impressions, and also on the amount of vitality and viability which it possesses. From this we learn, other things being equal, that as the development of the nervous system has not reached perfection in the infant, the impression and direct effect of shock in early age will be less felt; and that the viability being stronger, the power of recuperation and of tolerating or enduring injurious impressions will be greater. This statement is necessarily relative. The infant of a given age whose body contains twenty ounces of blood cannot part with half of that quantity with the same immunity as the adult can who is possessed of two hundred ounces in the system; yet the same infant will bear the loss of five ounces of blood better than the adult will that of fifty ounces, the amount lost in each case being the fourth part of the circulation; and also, an infant whose surface may be supposed to be equal to four square feet will support the effect of a severe burn extending over a portion of the body the size of half a foot square better than the adult of sixteen square feet of surface will bear a burn of equal severity of the extent of two square feet, each suffering from injury to an eighth part of the surface.

Comparative anatomy teaches us that the human embryo in its growth passes successively through a series of gradations of rudimentary forms, each one of which, to a certain degree, represents the full development of a class of animals placed lower than itself in the zoological scale; and that as the creatures representing the inferior types of the animal creation are approached, sentiency is found to be less perfect, while viability is more energetic and persistent. If this be conceded, and the inference carried forward, the influence of shock upon the system will be accordingly more or less modified by age, from the period of the full development of the embryo at birth,

through the several stages of the first and second infancy, of youth, and of adolescence, up to the age of maturity, when the extreme perfection of human development is reached. Here the equilibrium of the functions becomes established; repair and waste, assimilation and disassimilation, progress with equal pace; the *nisus formativus* is at a stand-still, and the system during this physiological pause maintains a negative position between progressive and receding vitality under the action of extraneous influences. Heretofore the impression has prevailed, and been advanced by many, that at maturity the system is better constituted to bear the effects of shock; but I am satisfied that such is not the case, precisely because the mind has so much to do with the result in accidents or injuries, and that at mature age sentiency is greater, while viability is less than in early life.

Without coinciding altogether with the doctrine laid down by Meckel, Serres, and Geoffroy St. Hilaire, that the human fœtus passes through conditions of transition at each of which the definitive constitution of the different beings which are inferior to it in the zoological series is represented, it is apparent that the human organogeny, in the different epochs of its progress, is an abridged illustration of transitional comparative anatomy. Thus M. Serres asserts that the monads among the inferior animals are represented in embryogeny by the vesicle of Purkinje; that the gones, the volvoces, etc., find their representatives in the primitive embryonic state. There is an apparent identity amongst the embryos before they are organically characterized, as there is, also, an apparent similitude or identity at the early period of development among the ova of all animals. The organization of the fish, of the reptile, of the bird, of the mammifer, and of man is, at the early or initial phase of embryonic life, the most simple expression of the type common to all. As soon as any visible trace of animal organization is manifested upon the blastoderm, this trace offers at once a characteristic and different type for all the individuals of each of the four grand divisions of the animal kingdom. In the vertebrata, to which man belongs, it consists of the appearance of a primitive line, and as soon as the ovum has reached in its development the period of the blastodermic membrane stage, and this line is indicated, it can be assumed that a vertebrate will spring

from this egg. Thus the first embryonic lineaments and organic dispositions of the nervous, the vascular, and the digestive systems are entirely analogous in all the embryos of the vertebrated class—the fishes, the birds, the reptiles, and the mammifers, including man. The analogy can be traced among the several embryonic organizations embraced in the different divisions, classes, orders, and genera of the animal kingdom. From what has just been stated it will be seen that the laws of development, and the peculiarities in reference to sensibility and viability belonging to the inferior individualities of the animal creation, afford a physiological basis for a surgical law or deduction by which we may estimate the relative tolerance and vitality of the system at the different ages under the influence of severe impressions, whether resulting from accidental injuries or from important lesions, such as those necessarily required during capital operations. While impressibility in some of the lower types of the animal creation is but small, vitality is so great that the capacity for self-restoration is manifested after a portion of the body has been removed by accident or design. Some even have the fissiparous power, by scission, of reproducing an entire living being similar to itself from sections made of the primitive animal. In general, the power of recuperation, and of repairing and reproducing lost parts, in the animal economy, increases inversely as we descend from the higher to the lower parts of the animal scale.

In man, and in the higher and warm-blooded vertebrata, the power of restoring lost component parts and organs is totally or almost entirely wanting. The stratified tissues, however—the epithelium, the epidermis, the hair, and the nails—are reproduced continually; and even when there is loss of substance in the fibrous, osseous, and other tissues, the loss, when not too extensive, is often repaired in a longer or shorter time. Thus the cicatrices of the skin, of the fibrous and nervous tissues, and the callus of the osseous system, are regenerations in a great degree analogous to the structures which they are intended to repair. It has been asserted that in certain mammifers the crystalline lens has been reproduced when the posterior part of the capsule has remained intact, and also that in man even a partial regeneration of the lens has taken place after the operation for cataract by depression.*

* Burdach, *Traité de Physiologie.* Paris, 1837.

If from the superior vertebrata we descend in the scale to the reptiles, we find there the capacity for regeneration much more energetic. With them the mutilated trunk reproduces the entire organs which it has lost. There is almost indefinite regeneration of the fangs of venomous serpents, and it is known that lizards, orvets, seps, and geckoes often break off the tail, and that the loss is soon repaired: "Il est peu de lézards qui n'aient éprouvé cet accident; et on en reconnaît les traces à la brièveté, à la couleur plus terne, aux écailles plus petites, à la forme plus rapidement conique de la portion reproduite, qui pourtant, à la longue, devient presque absolument semblable à une queue normale. À l'intérieur, on y trouve peau, muscles, vaisseaux, prolongement nerveux, enveloppé d'un étui solide; mais cet étui n'est jamais divisé en vertèbres, ni même parfaitement ossifié; c'est un cylindre de cartilage auquel est incorporé un peu de phosphate de chaux."*

With young frogs and toads the *pattes* are reproduced. In the salamander this faculty of reproduction by scission is still more remarkable. With these animals, after mutilation, not only one foot is replaced, but all the four. In some experiments, after the tail was excised, a new one, with all its parts—skin, muscles, bones, vessels, nerves, and spinal marrow—was reproduced. Spallanzani has also observed the regeneration of the tail in the tadpole, and even that of the inferior jaw in the salamander.† Upon the authority of Bonnet‡ and of Blumenbach§ it has been stated that the eye of the salamander will be renewed within the space of a year, if during removal the optic nerve has been preserved, and a portion of the membranes of the eye have been allowed to remain in the bottom of the orbit. In experiments with fishes, the fins, when cut off, have been reproduced, after several stages of growth, in about eight months.

The phenomena of reproduction in the articulata, the crustacea, the insects, and the arachnides are even more marked. Examples are common of the shedding of the teguments of the larvæ of insects, and of the regeneration

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* Dugès, *Traité de Physiologie comparée de l'Homme et des Animaux.* Montpellier, 1839.

† Spallanzani, *Prodromo d' un Opera da Imprimersi sopra il Riproduzione d' Animale.* Modena, 1768.

‡ Bonnet, *Trois Mémoires sur la Reproduction des Membres de la Salamandre aquatique.* Neufchâtel, 1779–83.

§ Blumenbach, *Kleine Schriften.*

of the legs, the claws, and the feelers of the crab and lobster. The multipeds and spiders reproduce the limbs and the feelers, or antennæ, while the neuropterous insects, as the dragon-fly, are known to renew their feet, and the larvæ of the cockroach and beetle to regenerate their antennæ. For the mollusks, the tenacity of vitality and the regenerating power are even more extended, as may be observed in the reproduction of the arms of the cephalopods, the tentacula of the snail, etc. With some of the last-mentioned, the head, even, will be reproduced after decapitation, provided the nervous ganglions which lie above and encircle the œsophagus be left intact.

The self-reproducing capacity in certain species of worms is even greater and more surprising than in those animals previously mentioned. It is not only manifested in the regeneration of the feet and of the tail, but extends to the re-establishment of entire portions of the trunk or body. The naides and lumbrici reproduce promptly new rings on the posterior part of the body when this has been vivisected; and when the earth-worm or the common worm frequenting fresh-water is divided across the trunk, each half reproduces that of which it has been deprived. According to Bonnet and Roesel, the naides reproduce the head and tail ten or twelve times in succession, or consecutively in the order of their removal. A naid divided into six or more longitudinal segments gives origin to an equal number of new creatures having the same character. The *Nais proboscidea*, when divided transversely, in the course of three or four days constructs one animal like the original by the addition of a new head and a new *trompe* to the caudal extremity, and also forms another by building a new tail on the cephalic extremity. It is well known that some species of intestinal worms, as the tænia, when broken by accident, are renovated by the addition of new segments to the superior extremity as long as that has not been expelled. The planaria also, among the class of worms, manifest a remarkable faculty of reproduction. These are flat worms, sometimes living in or indigenous to fresh-water, sometimes found in salt-water, and bearing analogy to the doaves, the amphistomes, the distomes, the tristomes, and other intestinal worms of the same class. Dugès, in regard to them, gives as the result of his various experiments: "Soit qu'on divise les planaires transversalement, soit qu'on les coupe oblique-

ment, ou dans le sens de la longueur, pourvu que le fragment détaché n'ait pas moins de la dixième partie du total, ce fragment devient bientôt un animal parfait." From Dugès's experiments it is seen that the tendency in them to complete restoration surpasses that shown in other species of worms, as the reconstruction takes place irrespective of the transverse direction of the section.

Among the radiata, as with the echinoderms and the star-fish, a segment taken from the body is regenerated with all the viscera. Moreover, according to some authorities, the star-fish not only reproduces one of the rays or bars of its body when it has been detached, but from a single one of them, when it is complete—that is to say, when care has been taken to preserve all the parts intact up to the axis or centre of its body—it will promptly reproduce the other four, and form an entirely new animal.

With the actinia—the genus of fleshy polyps, including the animals ordinarily called sea-anemones, which approach the lowest grade in the zoological scale—the aptitude for partial reproduction is still more marked, and in this respect reaches the maximum. Taking the hydra as an example, all the parts of the body of this animal can be equally replaced, in whatever direction it may be divided, whether it is cut across longitudinally or in many strips. According to the remarkable experiments performed by A. Trembley in 1744, we learn that, having divided a hydra in the direction of its length, he saw at the termination of an hour the form of the animal reproduced; after three hours this new production began to eat, but as yet it possessed no arms: they became developed afterward. Trembley carried his experiment farther: he divided several hydras into small portions in every direction, and each of these portions soon became an entire hydra. Thus, whether the division was transverse or longitudinal, the part of the polyp detached, equally in each instance, became complete; each section formed branches, developed an alimentary canal, and re-formed an entire polyp. Moreover, by incomplete division, Trembley obtained a multiplication of forms; but the multiple developments were also incomplete—that is to say, when confined to the divided portions. He thus obtained hydras with two heads, with three heads, and even with as many as seven heads. But at the same time Trem-

bley observed and pointed out the existence of a great difference in respect to redintegration between the different sections of the polyp. Although the vital properties may be equally distributed through all the portions of the body of the hydra, and may maintain therein an equal force, yet some of these parts, presenting in this small animal a special peculiarity of organization, are, from this very fact, not suited to serve as new points of departure for an organized reproduction. Thus Trembley saw that the sections of the body and of the head, however small, and in whatever direction they might be cut, could reconstruct a hydra; but he also observed that the arm of the animal, though it continued to live in water, was incapable of forming a new hydra.*

If this brief statement of the history of development, and of the peculiarities which are manifested in the different gradations of the zoological scale, descending from the higher classes to the lowest types, be correct, it must be admitted that a great diversity exists among them in the capacity and persistency of sustaining life, under the pressure of antagonistic agencies; and under external influences of a deleterious character; and, moreover, that the law heretofore mentioned is confirmed—that in the animal creation the activity or intensity of vitality and the power of recuperation and of self-reproduction are greater in the inverse ratio of the degree of development and of the age of the individual. In emerging from intra-uterine to extra-uterine existence, the young human being is still very far from having reached its ultimate development. It has yet to pass through the several gradations of continued life, and to be subject to the biological laws which preside over the animal kingdom generally, and, according to analogy, while endowed from imperfect organization with less sentiency, it must be credited with greater vitality, than its more matured immediate progenitor, possessing, as it must, to a greater degree in the early period of life the pre-established principle or element of formative growth.

In addition to what may be learned from comparative anatomy and the natural history of the inferior types of the animal creation, experiments made by vivisection, the tolerance of suffering exhibited under severe surgical op-

* Trembley, *Mémoires pour servir à l'Histoire d'un Genre de Polypes d'Eau douce à Bras en Forme de Cornes.* Leyde, 1744, avec Figures.

erations, as also the greater endurance manifested while passing through the tedious progress and exhaustive influences of protracted maladies, establish the fact that young persons possess the largest amount of vitality when subjected to the shock of severe injuries. After decapitation of young vertebrated animals, such as the mouse, the rat, or the dog, it is found that they retain the signs of vitality, and the capacity of manifesting the reflex action of impressions, for a longer period of time than animals of the same type that have reached the age of maturity. In frogs, after removal of the head, the excess of vitality is observed in a remarkable degree; and for this reason these animals, in their early stage of existence, are often selected by physiologists for illustrating by vivisection the experiments connected with the functions of the excito-motor system.

Leaving the lower types of the animal kingdom, we have examples of the new-born infant affording extraordinary evidences of vitality in the resuscitation which is accomplished by persevering efforts to restore animation by artificial respiration in cases of apparent death from apnœa, resulting from the prolonged detention of the head during tedious labors, or from abnormal presentations. Repeatedly, in cases requiring the turning of the child or the use of the forceps, I have seen life restored when apparently there was no room for hope.

An unusual case, illustrative of great vitality in the early months of infancy, came under my treatment a few months ago.

Case.—In January last I was called to a distant part of the city to see an infant, four months old, who had been laboring under a peculiar œdematous inflammatory swelling, extending around the sublingual and submaxillary regions as far back as the upper portion of the larynx. The tongue was pushed backward by the prominence of the swelling under it, so as to produce partial closure of the rima glottidis. The infant naturally was of feeble constitution, and the affection had been gradually growing worse during the previous two weeks. The mechanical result of this œdema among the tissues was to produce great dispnœa, and other symptoms resembling those of membranous croup. The lungs were only affected by the immediate results of the apnœa. The face of the child was purple and suffused, the eyes staring; great

restlessness, with throwing back of the head; the respiration not stridulous, but resembling more the croaking of the frog. There were signs of hunger, the child spasmodically at times taking hold of the nipple; but this was much hindered by the position and partial immobility of the tongue. The only alternatives in this anomalous condition were tracheotomy, and free scarifications down to the submucous cellular tissue along the seat of the engorgement. There was a considerable degree of swelling externally on the neck below the chin, and also along the lower margin of the under jaw; and as the impediment to respiration did not threaten life immediately, I preferred to use the scarifications, and to trust also to the use of medication to bring about a timely resolution. I was not disappointed in this expectation, for I was informed next morning that the child was much better, breathing more freely and nursing without difficulty. This favorable turn in the symptoms continued about four days, when a relapse occurred, and I was again requested to see the child. A new condition of the disease had appeared. The œdema and swelling around the base of the tongue were much diminished, but the difficulty of respiration had again returned, caused, however, by a hard swelling showing itself externally in the lower part of the parotideal region and extending downward on the side of the neck below the angle of the jaw, and protruding inward so as to encroach upon the cavity of the pharynx and the upper orifice of the larynx. The lungs were now becoming congested, but were still free from bronchial or pneumonic inflammation. The patient had become very feeble, and the symptoms were imminently dangerous. Tracheotomy was indicated, but deferred, on account of the objection of the parents to the operation. I left the patient, to return in the evening, recommending a warm poultice over the region of the swelling, and weak brandy and water with carbonate of ammonia to be given in such quantities as the difficulty of swallowing would allow—a piece of linen moistened with the mixture and passed into the mouth to be at times used instead of the spoon. On my return I found that the disease had assumed still another phase. The swelling had increased, and deep fluctuation could be felt. Breathing was more difficult, and on looking into the mouth I found the posterior part of the pharynx still more obstructed. The impediment to breathing was so great that it

was apparent the child could survive but a short time if relief was not obtained. On passing the finger backward and downward into the pharynx, a soft fluctuating tumor could be felt protruding inward toward the mesial line, and extending farther laterally behind the box of the larynx, seemingly large enough to occupy the posterior part of the pharynx; in fact, a latero-posterior pharyngeal abscess had fully formed. The indication now presented was to give immediate egress to the purulent collection. This was effected by passing a narrow bistoury, with a wet strip of linen wrapped around the blade to within an inch of the point, and guided by the index finger, rapidly to the front part of the surface of the swelling. The instrument was then thrust into the cavity of the abscess and carried inward, so as to cut an opening of an inch in extent through the wall of the sac. The matter freely followed the withdrawal of the knife, some escaping into the cavity of the mouth, and some passing down the œsophagus. The infant was for a time apparently suffocated, but soon showed signs of improved respiration. The mouth and pharynx were cleansed frequently by passing the finger covered with wet linen and a moistened sponge-probang over the buccal and pharyngeal cavities. The tumor collapsed as the matter escaped, leaving the pharynx comparatively free. In a short time, however, signs of collapse appeared from exhaustion, and during the next two hours the patient continued gradually to sink, and finally to all appearance life became extinct. The family physician (Dr. Pilgrim) believed the child dead. I was of the same opinion. The mother, thinking that all was over, left the chamber, to mourn in private. The father took the supposed dead child in his arms, and entreated me in his agony to endeavor to bring it back to life. I was packing up my instruments that had previously been laid out for tracheotomy, and more to quiet him than with any hope of success, I determined to make a forlorn effort to resuscitate the child. Abruptly telling him to sit down and place the child in a recumbent attitude across his knees, I seated myself on a low footstool opposite, and began to promote artificial respiration. I continued this unavailingly for some minutes, compressing the ribs, and permitting alternately their expansion by sudden removal of the pressure, turning the child from side to side, and elevating at times the arms above the

level of the head. Several minutes elapsed, when suddenly a feeble gasping sigh or abrupt inspiration took place. A long pause of some two or three minutes occurred, the artificial efforts being still continued; and this was succeeded by another spasmodic gasp, another pause of similar length, and another abrupt gasp for breath. For nearly an hour the different measures for maintaining artificial respiration were kept up, when the infant began to manifest unmistakable signs of spontaneous respiration. The intervals between the inspirations became shorter, and the child began to make feeble struggles or voluntary movements, and from time to time to utter faint cries. The signs of returning animation became by degrees more energetic, the slowly returning heat of the surface, which had been cold as death, showing evidences of reaction. The mother was called in, and took the infant in her arms; respiration continued to be more naturally performed; and in little more than an hour from the time that artificial respiration was commenced, the child took hold of the nipple and nursed. The signs of collapse and of apparent dissolution slowly disappeared, and reaction gradually became completely established. This patient was very much exhausted by the prolonged illness it had undergone, and the operation of opening the abscess, although trivial under other circumstances, no doubt brought about the collapse which so nearly proved fatal.

The question regarding the influence of age upon surgical operations has engaged the attentive consideration of some of the great masters of surgery, and it has been generally stated by them that the young tolerate badly the shock following after serious operative procedures. Thus Lisfranc taught: "On évitera d'opérer les enfants en bas âge, à moins qu'il ne s'agisse d'une maladie qui ne permet pas de temporiser; ..... à cause de leur faiblesse, les pertes abondantes de sang sont plus inquiétantes."

The abstract assertion is no doubt correct that a child cannot support all the effects of a severe operation or of an equal accidental injury with the same immunity as the grown-up individual—that is, if it has to part with the same amount of blood as the adult, or if its diminutive surface is to be submitted to a similar extent of lesion, as in the case of a burn of equal dimensions, as heretofore stated. The child has not the capacity in its circulatory

system to contain as much blood, nor has it as large a physical organization to secrete the sustaining nervous fluid; but what there is of it is of a more persistent and energetic character, and relatively there is greater power of endurance. As illustrative of the danger of operations on the young, J. L. Petit relates the case of a very young patient, on whom the operation for hare-lip was performed, and who succumbed during the process. The autopsy showed the presence in the stomach of a great quantity of blood, which had been swallowed without the assistants' taking cognizance of the circumstance, supposing the child had gone to sleep. This result might have been expected from the inattention of the operators, and admits of the simple explanation that the child sustained a loss of blood incompatible with vitality, or too large in quantity relatively to the capacity of its organization, and out of proportion to the contents of the circulatory system. Observations in hospital and private practice attentively made prove conclusively that operations are supported better, and recoveries take place under similar circumstances more readily and more frequently, in young patients than with adults. Examples of this are met with in almost all the capital operations which are performed on patients during the early periods of existence. It is well known that the operation for lithotomy is rarely fatal when performed properly on the young subject. The same may be said in regard to harelip, which, when double or complicated, is often a very formidable affair, and yet it is generally followed by union by first intention. So with operations for the ligature of large arteries, as tying the carotids, sometimes required for nævi of the orbit, as well as for nævi of large size in other localities; for amputations; for resections; for strangulated hernia, when that condition occurs in early life; and for trepanation of the skull for depression of bone. Even in cases of congenital deformities, where success is scarcely to be desired, we find union by first intention occurring, as in exstrophy of the bladder; and so far as the mere formation of an artificial anus is concerned, colotomy is generally followed by success. Staphyloraphy is often successful in the young, when performed as soon as the will of the patient can be subjected to control; and paracentesis abdominis, frequently required in the young, although often indicated to relieve serious internal

disease, is well tolerated as a general rule: and I may here state that during twenty-two years of continuous hospital practice, while surgeon-in-chief to the State Emigrant's Hospital, then the largest in the country, as well as while professor of surgery, holding biweekly clinics at the College for ten years, and at the same time with an extensive private practice, where I performed of course many operations, I am confident that I never lost a patient operated on in early life. Many cases of harelip in its various phases —simple, compound, and complicated—came under my care, and by taking the precaution of having the facial artery compressed as it passes over the base of the lower jaw by an assistant, who at the same time steadied and supported the head, and by using metallic sutures, I have not failed in procuring union by first intention and a favorable result. The time of life generally selected for such operations is during the first six weeks after birth, or, at farthest, before symptoms of dentition begin to manifest themselves.

I submit the following cases in brief, as more directly to the point than experiments made by vivisection upon the inferior animals:

Case.—Burtnett; boy, twelve years of age, residing with his parents in College Place, of healthy temperament, while playing in the gymnasium attached to his school was struck on the left temple with the corner of the wooden seat of a swing while in rapid motion, and received a compound fracture of the skull, with depression of bone to the extent in size of a silver dollar. I saw him about two hours after the accident. He was insensible, breathing stertorously; pupils irregularly dilated; jactitation at times, with convulsive contraction of the muscles; cold surface, and the other usual symptoms of shock followed by collapse. By removal of a portion of bone with the crown of a small trephine, room was given for the elevator to act, and the depressed bone was raised to the natural level of the cranium. Gradually the symptoms of concussion and depression subsided, cicatrization of the wound speedily followed, and the patient had a complete recovery, mentally and physically.

Case.—Crabtree; boy, twelve years of age; active temperament; was jumping off the cars of the Harlem Railroad while in motion, and fell under the wheels of the cars, having his right leg crushed, the bones smashed, and

lacerating the other tissues to within a short distance of the knee. He was carried into the depot near by, and the collapse was so complete that he was supposed to be dying. I happened to be in the train at the time, on my way to a professional call, and saw him immediately after the accident. The oozing of blood from the wound was stopped by an impromptu garrot, and the limb amputated midway between the knee and the hip joint while apparently in a dying condition. Dr. Freeman, of West Farms, whose residence was in the vicinity, remained after the operation many hours with the patient, keeping up artificial respiration, and administering cordials by drops and by wetting the mouth with a piece of linen dipped in the liquid. The accident occurred in the afternoon, and the patient was laid in bed from the operating table about 4 P.M. There was but little reaction until midnight. At this time signs of recuperation commenced, and by morning the surface had become warm, the pulse was perceptible, the breathing natural, and the intelligence, although dull and obtuse, was slowly returning. Reaction became entirely established by evening, and nothing occurred to retard the cicatrization of the flaps. The patient was taken out to drive in about three weeks, and was quite well at the end of a month from the time of the accident.

CASE.—A boy, nine years of age, was brought into the State Hospital while I was making my usual visit, having been run over by the wheels of one of the Third Avenue cars. The accident had occurred about three hours before I saw him. The right limb was completely crushed from the middle of the leg up to the knee. A considerable quantity of blood had been lost between the occurrence of the injury and the transfer to the hospital, and upon his admission he was apparently moribund. The patient was sent to the operating room without delay, and amputation by double flaps was performed midway between the knee and hip. The amputation was made during the afternoon. Artificial respiration was kept up, with the administration of cordials, during the night. By the next morning reaction began to be manifested, and by evening the symptoms were all improved. Cicatrization went on without complication, and in less than a month the patient was discharged from the hospital completely cured.

CASE.—Mersereau; boy, sixteen years of age, residing with his parents

on the north side of Staten Island; while out duck-shooting in a boat along the shore had his right upper arm badly injured by the accidental discharge of his fowling-piece. The humerus was shattered from the insertion of the deltoid to the elbow-joint, the fracture extending longitudinally into the joint. The humeral artery, nerves, muscles, and other tissues were very extensively and severely lacerated. Dr. Clark, of New Dorp, the family physician, had seen him, and restrained the hemorrhage, and had administered cordials; but reaction had not been established when I saw the patient the following day. An operation was decided upon in consultation, and I removed the arm at the lower part of the upper third of the humerus by the double-flap operation without farther delay. This patient had a complete recovery in about three weeks, without any intercurrent complications.

Case.—B——; boy, aged fifteen; residing with his parents in New York; had been suffering from ostitis of the lower two-thirds of the femur, with expansion of the bone and sequestra, with internal suppuration of the bone, and extensive collections of pus among the soft tissues of the thigh. Amputation was performed high up on the thigh above the disease by the double-flap operation. On account of the softened condition of the tissues through which the incisions had been made, secondary hemorrhage occurred on the sixth day after the operation. To arrest this, the common trunk of the femoral artery was tied below Poupart's ligament. The hemorrhage was arrested, and this patient, though extremely reduced by prolonged suffering and exhaustive discharges, recovered entirely without farther complications taking place.

Case.—Beames; boy, about fifteen years of age; son of the organist of St. Bartholomew's Church; residing with his parents; while endeavoring to get on the front platform of a University Place car, slipped, and was run over. The upper part of the right leg and lower part of the femur, including the knee-joint, were crushed, and the blood-vessels and soft tissues badly torn and lacerated. He was carried into his father's house near by, and I saw him about two hours after the accident. The family physician (Dr. Dixon, of Fifth Avenue) had seen him, and administered restoratives. Before medical assistance had been procured, however, the patient had lost a

great deal of blood, and his collapse was very profound. Amputation of the thigh beyond the seat of injury, by double-flap method, was promptly performed, carefully avoiding farther loss of blood. No unfavorable symptoms occurred during the after-treatment, and in a month the patient was well.

The histories of cases of severe accidents where operations are not required serve also to prove the same fact. Instances of recovery often occur in the young when from the accident or circumstance which caused the injury, such as a fall from a great height, only a fatal result could be expected.

For example: Sharpe, a boy about six years of age, residing with his parents at the St. Omar Hotel, while playing in the fifth story, during the momentary absence of his nurse, perched himself upon the edge of a window that opened on a ventilating shaft. Losing his balance, he fell to the ground-floor, a distance of seventy-five feet. In passing through this space he came in contact with a plate-glass skylight, a quarter of an inch in thickness, that divided the lowest story from the one immediately above. The impetus of the fall carried him through the glass, making an irregular aperture about the size of his body. He was picked up, bleeding and senseless, and carried to his mother's apartment, where I saw him about an hour after the accident. The family physician (Dr. Baralt) was already with him. He was fearfully lacerated and gashed about the face—the ossa nasi and superior maxillary bones broken and driven inward, and the lips and labial arteries divided, from which he had lost a considerable quantity of blood. The general surface of the body was badly bruised, and there were several large lacerated wounds on the trunk and extremities. The right femur was broken through the upper third. The several cuts about the face and limbs, so extensive as to require stitches, were brought together by interrupted sutures, and compresses, wet with an evaporating lotion, laid over the surface. The fractured limb was adjusted, and retained in position by a modification of Desault's straight splint. Proper measures were used to bring about reaction. The accident occurred in the afternoon, and reaction was established by morning. The patient progressed without any adverse indications; and in five weeks—as soon as the fractured femur was sufficiently united—he was allowed to commence walking, and had a speedy recovery.

Case.—Moulton, a child between three and four years of age, took advantage of the temporary absence of its nurse to climb upon the sill of a window that happened to be open, and fell into the area below, a distance of over twenty-four feet, striking on the stone pavement. I saw him about an hour after the fall. All the symptoms of concussion with collapse were present: insentiency; cold surface; weak, irregular pulse; spasmodic twitching; contracted pupil; and the respiration very feeble and somewhat rapid. After some hours, external heat having been applied and cordials administered, there were signs of returning animation, and reaction became established. In a few days the child was playing around as usual, and complete recovery followed.

Case.—Gray, a child aged six years, son of a gentleman residing at Bath, Long Island, tried to pull some hair from the tail of a horse that had just been shod. The animal gave the boy a kick with the hind hoof, striking him full in the face, and fracturing and displacing the entire osseous formation, including the ossa nasi, superior and inferior maxillary bones, the ethmoid, turbinated, and lachrymal bones, and the zygomatic arch of the temporal bone on one side. The gashes of the soft tissues were fearful, one dividing the entire upper lip through its thickness, passing upward along the side of the nose. I saw the patient about six hours after the accident, in consultation with Professor E. H. Davis, of this city. He was in a state of stupor and collapse; had lost a considerable quantity of blood, especially from the labial artery. The bones were put in place, the cuts carefully adjusted, and kept in position by metallic sutures, and linen compresses, wet with a cooling evaporating lotion, placed over the parts. Under the influence of cordials, gentle friction along the extremities, and warm flannels, reaction set in after a few hours, and by the following morning was established. This child speedily recovered without complications, and with comparatively small disfiguration.

Case.—On the 16th June, 1878, a girl (E—— B——), fourteen years of age, having an errand to perform in the upper part of the dry-goods establishment of Messrs. Lord and Taylor, tried to ascend in the freight-hoist, or elevator. As it was very much crowded, she stood unconsciously with the left heel projecting over the edge of the platform, and in the ascent her foot

was caught between the floor of the platform and the framework of the opening on one of the upper floors. The elevator was immediately stopped, and the foot extricated, but in a fearfully mangled condition. She became insensible from the shock, and remained so for about four hours, with signs of severe collapse. A neighboring physician was called in, who placed a light dressing on the injured parts, and ministered to her sinking condition. She was carried to her home, when I was called in, and saw her about two hours after the accident. The gaiter boot that she wore was burst open, and the sole twisted and rent to pieces by the pressure. The foot was bruised from the heel to the toes. The whole outer side of the foot was crushed into an apparently disorganized mass. The bones of the metatarsus were broken, and the soft tissues of the instep, as far as the junction of the foot with the leg, and of the sole of the foot from the heel to the toes, were for the most part destroyed to the depth of from a quarter to half an inch. Although consciousness returned in about four hours after the receipt of the injury, the symptoms of collapse continued with but little improvement for several days. Probably from the additional influence of the progressing gangrenous condition of the parts, on the fourth day the signs of exhaustion became aggravated, and she was for some hours supposed to be dying. Under the administration, however, of opium, brandy, and carbonate of ammonia she rallied from the state of depression, and reaction, followed by traumatic fever of a typhoid character, became established. Locally, the sloughing foot was daily painted freely with balsam of Peru, and a light dressing spread with an ointment composed of one ounce of simple cerate, half an ounce of unguent. basilic., and two drams of the balsam Peru was applied over the gangrenous parts. During the stage of collapse, it was a matter of doubt whether I should amputate the leg; but as soon as reaction became established, relying on the recuperative powers of early life, I deemed it proper to use efforts to save the limb. The system was supported by quinine, brandy, and wine. Soon suppuration took place; the sloughs gradually became detached; and on the 9th of October she was able to leave her bed. On the 16th of the same month, the middle toe, the denuded phalanges alone remaining, was amputated at the metatarso-phalangeal joint. The wound healed kindly; and three weeks

after this minor operation, general cicatrization having been completed, she was able to walk about with ease and comfort. During the long period of confinement, from June to October, this patient suffered from great constitutional irritability, resulting from the original shock to the system; but the recovery was perfect, and there is no resulting mutilation, except the loss of the third toe, which was amputated, and two phalanges of the second toe that dropped off during the period of sloughing. At the present time (June, 1879), one year after the accident, she can run, skip, and jump, and her movements are as free as if no accident had happened to her.

Case.—I—— P——, a youth fifteen years of age, residing with his parents in the upper part of the city, while standing as a looker-on at a game of base-ball, in the Central Park, was struck on the face by a bat, which had slipped accidentally from the hand of a player in the act of striking with great effort at the passing ball. The end of the bat, which flew swift as an arrow, struck the centre of the face, lacerating the soft tissues, breaking and displacing backward the facial bones covering a space bounded above by the frontal sinuses and the inner part of the frontal border of the orbits, below by the teeth and the alveolar margin of the upper jaw, and laterally by the line of fracture passing through the central portions of the malar bones. There was thus produced a general comminuted fracture, involving the inferior part of the frontal bone, the ossa nasi, the lachrymal bones, the orbital plates and turbinated bones of the ossa ethmoidea, the vomer, the inferior turbinated bones, the superior maxillæ, and malar bones. There was not much bleeding. I saw him about two hours after the accident. He was in a state of deep stupor and extreme collapse. Restoratives were administered, and the usual measures adopted to reanimate the vital energies, and the displaced bones were readjusted to their normal position as far as possible by the use of the ordinary dressing forceps, passed closed into the nasal cavities and used as an elevator. It was difficult to replace the fragments of the ossa nasi and the ascending processes of the superior maxillæ. These parts were so wedged in among the other osseous structures that they could scarcely be moved by means of the instruments. After some effort, however, they were placed in position. The constitutional symptoms re-

mained unfavorable for over forty-eight hours. The stupor continued, and the vitality wavered so as to render recovery doubtful. The signs of reaction at length began to appear, and in the course of the following two days considerable improvement in the symptoms took place. After this time the patient gradually recovered, the osseous structures becoming consolidated, and the soft tissues, where the lacerations and other wounds had been received, uniting kindly, and with comparatively little disfiguration.

In following the commencement, progress, and termination of some of the chronic surgical affections that attack the young, the general fact of the superior capability of patients in early life to withstand the effects of prolonged suffering and exhaustive discharges will also be observed. In such diseases as morbus coxarius and chronic strumous affections of the other large joints, it is not uncommon to meet with cases in children who have passed through the different stages of these formidable maladies, and have had favorable recoveries after years of tedious suffering and suppurative inflammation, associated with exhaustive complications, such as frequent diarrhœa and hectic. The same may be said of those who have undergone the distressing phases of caries of the spine, or Pott's disease, the little creatures emerging from their severe ailments with spinal deformity, but with the average share of health allotted to those who have been from birth tainted with morbid diathesis. Similar instances are also met with in the young who have been subjected to the ordeal of severe ostitis of the long bones, followed by caries and necrosis, with the attendant complications of extensive abscesses among the soft tissues, and the consequent chronic suppurative discharges.

In diseases strictly medical, similar facts are also observed. Children are at times attacked with rheumatism associated with endocarditis and disease of the valves of the heart, with deposit of granular or pedunculated bodies on the surface of the cavities of the heart, or, as often happens, on the mitral valve. Such cases are marked by abnormal cardiac *bruits*, by febrile exacerbations, hot and dry skin, vitiated appetite, emaciation, œdematous swellings, and abdominal dropsy. Patients affected in this manner will often linger for years, tolerate with unexpected endurance repeated tappings, give signs of

recovery, and seem sometimes to overcome the numerous complications of disease under which they pertinaciously struggle; and if they do at last succumb, it is only from the irremediable organic changes which have taken place in the cardiac valves, or from the effects of embolism occurring in the arteries of the brain, or in some other parts of the arterial system, as a result of the detachment of portions of fibrinous deposit from the lining membrane of the heart or from the cardiac valves, and their convection into the general circulation, producing *ramollissement*, or softening of the cerebral structure, with subsequent intracranial effusion of blood, or some other pathological change. The physiological facts previously mentioned supply the basis of an inductive analysis of the pathological details presented in the preceding cases. If necessary, many similar instances could be cited in corroboration of the statement that shock and collapse, occurring from whatever cause, are better supported in the early stages of existence than at a more advanced period.

Old age, or the decline of life, is unfavorable to the tolerance of shock and collapse. After the period of the menopause in the female is passed, and the epoch of general equilibrium of functional development and full maturity of the organs of the body—approximately, between the ages of forty-five and sixty years—is reached, a new phase begins slowly to come over the physiological condition of the system. Instead of the formative power being in the ascendant, the organs and tissues, the sources from which emanate the manifestations of vitality, undergo a retrogressive development in their physical structure, and perform their functions with diminished activity, the nervous forces that are dependent upon their integrity are less freely supplied, and are less intense in their action and less capable of resistance, and the inherent antagonism to the baneful influence of non-natural and deleterious causes ceases to exert the power that it wielded during the exuberant vitality of early life.

A source of error is likely to arise, in the aged, from their apparent insusceptibility to and tolerance of the effects of severe shock. In the descent from the passive age of middle life to the later stages of existence, which end as extra-uterine life began, in feeble physical sensibility and mental

dulness, the constitutional effects of severe injuries are imperfectly manifested. This apparent indifference of the system to the effects of shock may lead to the delusive supposition that lesions of a severe character will not be followed by an unfavorable progress and termination. The feebleness of the recuperative powers creates uncertainty as regards the ultimate effects of shock on the aged; and if the immediate results in them are not to all appearance serious at first, they must be considered as fraught with the dangers attendant upon the adynamic physiological condition peculiar to the later stages of life.

Notwithstanding the remarks just made, it must not be overlooked that age with some persons is only a relative term. Old men are met with who, possessing a perfect organization from hereditary transmission and from carefully regulated lives, maintain unusual recuperative abilities until an advanced age, and resist the effects of shock as well as those of juvenile years. This fact is especially observed in operations for cataract, for stone in the bladder, and for strangulated hernia, which are often well supported by very aged persons, when no constitutional complication is present, such as ossification of the arteries, or disease of some of the internal parenchymatous organs. A few years since I removed a large vascular tumor from the occipital region in an old man ninety-two years of age, abstaining from the use of anæsthetics, with a generally favorable result and rapid recovery. On the other hand, it sometimes happens, especially in large cities, that persons scarcely arrived at adult age, and possessing originally fair constitutions, are so broken down from youthful dissipation and excesses of various kinds that they are overtaken by early decrepitude and premature senility. Such persons do not tolerate well the effects of injury, and often fail to rally from collapse following severe shock.

The epochs of life generally associated with moral and physical perturbations of the economy of the system, viz., that preceding the age of puberty and that of the menstrual cessation, are unfavorable to the support of severe impressions following upon shock, and at such periods surgical operations of gravity should be postponed, unless a pressing necessity requires their immediate performance.

Anatomical Changes that Take Place at Different Ages.—Age modifies to such a degree the moral and physical condition of the individual that the anatomical peculiarities associated with each period should be understood. In fact, from the vivification of the germ until the occurrence of natural death, numerous transmutations are in continual activity in the system, which constitute a species of progressive and retrogressive comparative anatomy, and which have an important influence over pathological phenomena.

In the psychical description of the seven ages of man, Shakspeare has portrayed in concise sentences the prominent mental peculiarities belonging to the several phases of human existence. These epochs are marked by corresponding changes in the development and construction of the organization, which take place, *pari passu*, during the progress of life from the infant in the nurse's arms to the last scene that ends the "eventful history."

The general division of existence into three ages—that of youth, maturity, and old age—already alluded to, for practical purposes must be reduced to more narrow limits. The changes that characterize each will thus be better comprehended, and the subdivision into the six periods of infancy and of youth, of adolescence and of maturity, of old age and of decrepitude, will be more easily described. Even these changes do not take place with abrupt and precise demarcation, but to a certain extent are modified by race, by temperament, by the influence of climate, and by hygienic conditions. When the fœtus has reached its full development in the mother's womb, the transition from intra-uterine to extra-uterine life takes place, and from this time forward the new being assumes another phase of existence. While the fœtus rested in the matrix of the parent, the elements of its nourishment were elaborated by the organs appertaining to the mother, but at birth the necessity begins for its separate maintenance, and the organs undergo a modification.

Infancy.—The first cry announces the establishment of respiration, and simultaneously with this, the various other functions of the organism—the circulation, calorification, digestion, innervation, etc.—come into play. After birth and the section of the umbilical cord, the expansion of the lungs from the entrance of air, and the greater afflux of blood toward these organs, the anatomical disposition of the circulation becomes greatly changed.

The heart is pushed from right to left, and from above downward, in consequence of the greater distention of the right lung and the descent of the diaphragm; the foramen ovale becomes gradually closed, because the Eustachian valve is drawn from above downward by the descent of the diaphragm, and can no longer direct toward this orifice the blood of the inferior vena cava, in which the quantity, moreover, becomes less by the amount that was formerly received from the umbilical vein. The valve of the foramen on the left side of the septum auricularum, larger than the foramen itself, is also thrown back by the blood which flows into the pulmonary auricle. The right ventricle, at first smaller than the left, becomes the larger. The ductus arteriosus rapidly contracts, and by the third day is found obliterated, or closed by a clot, and is ultimately transformed into a fibrous cord. The umbilical arteries are also partly transformed into fibrous cords, which converge toward the fundus of the bladder to form its anterior true ligament. The umbilical vein and the ductus venosus, not receiving blood through the descending aorta from the hypogastrics and the placenta, become obliterated between the second and fifth days after birth. On the other hand, the pulmonary arteries are developed, and assume a larger calibre, the blood being continually drawn toward the lungs by the act of respiration. The infant having acquired an independent existence, the organs of digestion assume a change suitable for the preparation and assimilation of its own nourishment. The stomach becomes more horizontal after the first inspiration, and after the introduction of alimentary material it acquires a larger capacity. The small intestine becomes a powerful organ of absorption, while the large intestine increases in dimensions, and the rectum expels three or four times daily the material that it contains. The liver diminishes relatively in volume; its color becomes less deep, and it secretes bile profusely; and the gall bladder, which at first was cylindrical, takes the conical form that it afterward retains. The kidneys are proportionately voluminous, their weight to that of the body being as 1 to 120, while with the adult it will be as 1 to 240. The urinary bladder descends more into the pelvis, and the urachus becomes obliterated. The urine is excreted ten or twelve times daily; at first clear, colorless, and without

odor, it contains no urea; but benzoic acid can be detected. The temperature in the newly born—which is said to reach only to 32° Centigrade, or 89° Fahrenheit—is less elevated, and the capacity for generating heat more feeble, than during middle age. As a general rule, however, cutaneous transpiration is not abundant with infants, so that one inducing cause of cold surface is absent. Still, caution should be observed in this respect when the very young are subjects of surgical operations or severe injuries.

The pulsatory movements observed in the encephalon of infants indicate a generous supply of blood to that organ, which tends to promote its physical development and functional activity.* A number of impressions crowd upon the infant for the first time, but the cerebral structure, still imperfectly organized, receives them vaguely and indistinctly, notwithstanding that in mere weight the brain presents a volume proportionately greater than it will have later, the weight ranging to the body as 1 to 8, while in the adult it will be as 1 to 40. Gradually the infant learns to distinguish impressions, and commences to experience pleasure from some which it seeks to reproduce by automatic movements, while from others it perceives a sense of pain which it signifies or expresses by cries. Feeble signs of volition about the fourth month may be observed by certain movements and actions which it executes. The chant of the nurse becomes dimly recognized, and will lull the infant to sleep; but the senses are dull, and act with tardiness. At the end of the ninth month changes in the larynx increase the volume of voice, and the intellectual and moral faculties begin to show themselves, as may be observed by feeble signs of memory, and by smiles and tears, which denote the cognizance of pleasing or repulsive impressions.†

The termination of the first nine months of existence may be said to

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* At the anterior fontanel in the newly born, or at any age when a portion of the cranium is removed, as in the operation for trephining, or in hernia cerebri following wounds of the dura mater and brain, two distinctive cerebral pulsations or movements are perceived—one resulting from the systole of the heart and the synchronous pulsation of the circle of Willis at the base of the brain; the other from the act of respiration, the brain alternately rising up during expiration and sinking during inspiration. The latter movement results from the impediment presented to the return of the venous blood by the contraction of the chest and the resistance of the air during expiration. A similar movement results from the closure of the valves at the débouchure of the internal jugular veins under violent excitement or great exertion.

† *Vide* Longet, *Traité de Physiologie*, Tome II. Paris.

limit the early period of infancy, when the second period commences, and extends from this time forward to the eighth year. During the latter period, although the general type of infancy remains, several important physiological modifications occur in the organism. Respiration continues in a regular manner—less frequent, but fuller and deeper. The circulation is maintained as before, the pulsation of the heart and of the arteries becomes somewhat diminished in frequency, the cavity of the thorax becomes augmented, the heart becomes relatively smaller, the thymus gland begins to decrease, the capacity for generating heat is increased, and calorification approaches the adult standard. Liquid aliments and the maternal milk are no longer sufficient for nourishment, the phenomena of digestion become more intricate, mastication is a necessity, and the jaws are more consolidated, and supplied with teeth. Passing over the exceptional instances that are cited where infants have come into the world with teeth, the germs of the teeth at birth lie hidden in the jaws, and it is toward the age of eight or ten months that they make their appearance through the gums. During the earlier months of infancy the teeth do not reach the alveolar border; their emergence takes place from their development in height, and from the wearing through of the gingival borders from the friction and pressure to which they are subjected. This escape takes place in a constant and regular manner. They begin to issue in general on the inferior jaw, where first the median incisive teeth appear; then the corresponding teeth in the upper jaw show themselves, followed by the two lower lateral incisors; and then successively come the upper external incisors, the first molar, and the canine; finally, between the second and third years, the second small molar. These primary teeth are only temporary; underneath them the definitive or permanent teeth are being slowly developed, the growth of which is the principal cause of the falling out of the first set. While this physiological effort is in progress, a salivation, if not excessive, at least augmented, accompanies the egress of the teeth, and a hypersecretion, analogous to that of the gastro-intestinal mucus, which sometimes is present, induces diarrhœa. Moreover, there exists almost always a hyperæmic condition of the gums, of the salivary glands, and of the tissues of the mouth. The arteries which are distributed to these parts become en-

larged, often inflammation of the cavity of the mouth is produced, and it is not rare for grave maladies to supervene as a result. It is evident from what has just been stated that during the progress of dentition the system is laboring under a state of perturbation, which predisposes the infant to cerebral disturbance by reflex action, producing sometimes convulsions and other maladies that terminate fatally. It follows that after accidental injuries the latent predisposition may be started into activity, and that surgical operations, such as those required for congenital malformations, like harelip, or for incidental lesions resulting in loss of substance and deformity, as from cancrum oris, from burns, or from the injudicious use of mercury, should not be performed at this epoch of infantile life, unless they are for some reason positively demanded.

In connection with the accomplishment of dentition the stomach becomes more active, preserving, however, for a longer time the aliments introduced into its cavity, extracting the assimilated parts with a certain slowness, and thus the frequency of the desire for food is diminished. The bile is thicker, and flows in greater abundance; the fæcal evacuations are more yellow and more consistent, and at the same time less frequent. The lobules of the kidney are less separated; the urine possesses color and odor, and contains urea.

The spinal system, relatively preponderating in weight, like that of the encephalon, is histologically incomplete in organization, and develops slowly during the early months of infancy. The medulla spinalis is, however, in close communication with the terminal branches or periphery of the fifth pair of nerves, and is thus anatomically in a condition that predisposes to disturbance of its functions from sympathetic and reflex influence during the process of dentition. The initial acts of locomotion are little else than a succession of futile efforts marked by a series of falls, the result of feebleness of the nervous system, of the want of muscular power, the inability to co-ordinate the movements, and the indistinct appreciation of the relative distances of objects. At the end of a year generally the ability to stand alone is acquired, but it is not until the end of the second year that the muscles learn to obey the impulses of the brain so far as to sustain voluntary progression.

Youth.—The period of infancy for the boy and the girl terminates at the

same time—toward the seventh year—and that of youth begins. The terminal limit of this age is not the same for the two sexes: for the male, it extends to the sixteenth year; while for the female, puberty is attained in the temperate zones about the fourteenth year, although it may arrive under some circumstances somewhat sooner. The epoch of youth is marked by the disappearance of the transitory organs—the thymus gland, which is not replaced, and the deciduous teeth, to make room for those which are permanent. The formative force is manifested by less rapid but more durable progress. In order to keep pace with the development of the body, nutrition becomes more active, and the digestive function is performed with additional energy. This is promoted by the increased power gained by the muscular coat of the stomach and of the alimentary canal, and by the more abundant secretion of saliva and bile. Respiration is not so frequent, and is more perfectly performed, showing about twenty respiratory acts to the minute between fifteen and twenty years of age, against forty-four soon after birth. The circulation approaches the normal standard, descending to eighty or ninety pulsations in the minute, in contradistinction to the number of beats during the early months of infancy, when it ranges, for the first month, from 120 to 136, for the third month, from 115 to 125, for the ninth month, from 125 to 130, and at the end of the first year, at about 128.* The progressive activity of the formative power is also shown by the increase in the height and weight of the body. Considered as having gained about sixty centimeters of height during the first seven years, afterward the length will not extend per annum more than five centimeters for the boy, and four for the girl. The weight, however, increases proportionally more, the growth being about sixteen kilograms for infancy, while during the period of youth the average annual augmentation is about 2.25 kilograms for boys and 2.75 kilograms for girls from eight to twelve years, and about 5.50 kilograms with boys and 3.75 kilograms with girls from twelve to seventeen years of age.†

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* Authorities differ widely as regards the frequency of the infantile pulse. The above may be reckoned as the approximate or average number of beats at the ages given. *Vide*, on this subject, observations by Dr. Guy, of London; Professor Meigs (*Diseases of Children*); the works of Billard, Valleix, Becquerel, and Trousseau.

† Villermé, *Annales d'Hygiène Publique et de Médecine Légale.* Quetelet, *Sur l'Homme et le Développement de ses Facultés.*

Although ossification of the skeleton is not completed until the end of the sixteenth year, its advance is manifested by the greater density and solidity of the bones, as well as by the increase in length and thickness which the bones acquire, and by the extension of ossific deposit into the cartilaginous epiphyses. By the end of the second year the membranous formation along the lines of juncture of the sutures and at the fontanels is ossified; about the tenth year the diploe of the cranial bones is developed, and as adolescence approaches the shafts of the long bones become consolidated with the epiphyses.* The bones of the upper and lower maxillæ expand and enlarge in accordance with the new dentition, which is made up of larger and a greater number of teeth, eight large molars being produced more than previously existed.† As the body changes and grows, so does a change come over the psychical condition of the mind as youth is merging into adolescence. The muscular system is developed more in the boy than in the girl, and his color becomes browner, and the skin less delicate. His vitality is surcharged with activity. The mind revels in the vista of the future, and by anticipation accomplishes great deeds on the field of battle or in the Senate-chamber, without reckoning upon the difficulties and obstructions to be overcome in their attainment. The spirit of the young girl takes a different direction. All her thoughts are concentrated upon the means of being brilliant in society, and the methods of pleasing by her graces and her beauty. The duties of her toilet and the accomplishments that adorn society absorb her attention; all her sentiments are directed toward love and affection, and she is prompt to the performance of acts of tenderness and benevolence toward the feeble and suffering. The *morale* now plays an important part in the general economy when the body is subjected to disease or accident.

Adolescence.—About the commencement of puberty—at the sixteenth or seventeenth year for the boy, and at the fourteenth or fifteenth year for the girl—the age of adolescence begins, and may be reckoned to have its limit

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* Serres, de l'Institut, *Lois de l'Ostéogénie.*

† The first permanent large molar appears usually about the seventh or eighth year. At this age there are fifty-two teeth in the head, viz.: twenty deciduous; twenty permanent, beneath these; and the twelve posterior molars.

at about the twenty-fifth year. During the earlier part of this time the appropriation of nutritive material by the system continues to be in excess of the disassimilation which is going on, and at the later period the histological development of the tissues and organs progresses toward perfection, so that at the terminal limit of this age the maximum of physical and intellectual capacity of the individual is approached. At the beginning of the middle third of this epoch—about the eighteenth or twentieth year—after the epiphyses have become effaced, and while the osseous system is gaining solidity, it often happens that the body acquires a sudden and abrupt growth, and attains the ultimate limit in height. About this time, also, the last molar is generally added to the jaws, to make up the complement of the second dentition. While youth is merging into adolescence, however, the most important changes are observed in relation to the genital system. This transition is marked in both sexes by the appearance of hair on the pubes, by the increase of secretion in the sebaceous follicles, and in the general turgescence of the external parts. In the male, the testes enlarge, and the spermatic fluid is secreted; the vesiculæ seminales, the prostate, the corpora cavernosa, and the corpus spongiosum participate in the general growth, and rapidly attain the normal size. The beard makes its appearance on the chin; the larynx becomes developed, and the voice changes, and acquires the timbre of manhood. With the female, the ovaries become more voluminous; the uterus enlarges, especially toward the fundus; menstruation is established; the mammæ are rounder and fuller, and the nipple becomes longer and advances upon the areola, which now assumes a roseate tint. The young woman retains the whiteness and delicacy of skin; and the cellular tissue, infiltrated as in infancy with adipose material, preserves the character of roundness and softness of the body and limbs peculiar to the sex.*

Psychical changes are also manifested in accordance with the mutations that take place in the anatomical arrangement of the tissues and organs. The sexual affinities in a great degree preoccupy the mind. In the male there is a general expansion of benevolent feelings, associated with external

* Longet, œuvr. cit.

demonstrations of sentimental gallantry. The society of the opposite sex is full of attraction. His aspirations are more real, and he engages in undertakings of moment and importance, which are followed by the adoption and utilization of the efforts and means required for success. On the other hand, the adolescence of the maiden is often marked by a gentle sadness and pensiveness of demeanor, accompanied by a calm impassibility of countenance that conceals the happiness of reciprocal affection or the pangs of unrequited love. In solitude she creates an ideal which she fondly invests with all the graces and accomplishments her imagination can invent. In vague visions of the future she already anticipates maternity, and has commenced to love the babe which she hopes to bring forth and cherish long before it has begun to exist. Such psychical phenomena possessing the mind while the body is in a condition of health, it is evident that they will modify the symptoms when the system is suffering from the pathological influences and effects resulting from accident or disease. Education, however, greatly changes the sexual relations, especially with the female, and according to the nature of her domestic surroundings and parental example the mind will be moulded into habits of self-respect and refinement or the reverse, as in cases where moral obtuseness and obliquity predominate.

Adult Age.—Adolescence glides imperceptibly into adult life, extending from the twenty-fifth to the fortieth year. From thirty to thirty-five the physical growth and the functional properties of the organs and tissues have been perfected, and for a few years, as a general rule, on either side of this point the individual may be considered to have attained the ultimate limit of mental capacity and of bodily endurance. The prize-fighter, the athlete, the hardy woodsman, or the adventurous pioneer of the far West enters the arena or accepts the career which his ambition or his desire for gain has planned with enthusiasm and assurance. The soldier, the man of business in commerce, science, or finance, is full of the part to be played in the daily struggle for existence. The *morale* is strengthened and stimulated by the necessity for effort, prompted by love of family and home. Physical courage is at its height at this age; but a cloud of timidity and dread may overshadow the mind at the approach of danger to life, not from personal fear,

but from considerations of disastrous results to household and offspring. Byron, in his verses on the dying gladiator, graphically portrays this mental condition that takes possession of the severely injured. Lying in the arena, with the life-blood oozing from his body, he heeds not the applause awarded to the victor, nor the fact that he is about to lose his own life. His thoughts revert only to his rude hut on the Danube, and his Dacian wife and children, and so he passes away. In such unseen influences we may find a cause for the intensity of symptoms after injuries, not generally regarded, which may turn the balance between life and death in cases of severe shock.

Maturity.—According to hereditary transmission of constitution, and the favorable or unfavorable conditions of life in which the individual may be placed, adult age, at the thirty-fifth or the fortieth year, passes into the age of maturity, which, according to circumstances, terminates about the fifty-fifth or sixtieth year. The body has then reached that stage of existence when the appropriation or assimilation of new material by the system is equally balanced by the disassimilation that is in operation in the tissues. During the years of this epoch the anatomical and histological condition of man continues at its fullest development, and his intellectual faculties and external senses have attained the ultimate perfection of which they are capable. The limits of growth have been already fixed by a pre-established arrangement of his nature: the body can no longer increase in height; the muscles cannot acquire new fibres; the viscera cease to enlarge; and the organs of the senses and of intelligence do not further augment in size. The organs of secretion exercise their functions with activity sufficient to remove the organic elements which may be in excess, or otherwise they are chemically transformed into a substance comparatively useless, and form deposits of adipose material among the general tissues or among the duplications of the epiploon, where they remain nearly inert. This equilibrium in the performance of the functions, although rendering the system apparently more delicately sensitive and more liable to be disturbed by any deviation from the normal equipoise, does not impart greater immunity from pathological perturbations or changes. "C'est dans l'âge viril qu'en réalité la vie est l'équilibre instable entre les fonctions de nutrition et d'excrétion, entre les causes

d'acquisition et celles de déperdition ; équilibre bien instable, car à chaque instant il varie, à chaque instant il est troublé, et, en deçà ou au delà, si l'une des forces l'emportait sur l'autre d'une manière excessive, l'état de santé ferait place à la maladie."

It might also be inferred that as perfection of development has been reached, so the power to resist the influences of diseases and of injuries would also be greatest, and that there would be less danger to the system when subjected to the effects of severe lesions. As has already been stated, the ultimate sources of shock are sentiency, or the susceptibility to receive impressions, and an organism so constituted as to transmit and, at times, to reflect them. At the complete or full development of the organs, the impressibility being greatest, the effects of shock are felt more intensely, and are consequently more overwhelming to the system. Moreover, the metabolic power and resiliency of youth have waned, and the energy and recuperative influence of the vis formativus have diminished.

The temperature at this age may be regarded as the standard of comparison, and when taken by the thermometer placed in the axilla or under the tongue, according to Davy, generally stands at 98° Fahrenheit, subject to variations within the limits of health of about 0.5° below and 1.5° above. The pulse also at this period may be considered as having reached the standard of comparison, and in the healthy man entering upon mature age may be reckoned as numbering from 70 to 75 beats to the minute. Each respiratory act is computed as consuming as much time as is required for the completion of four cardiac pulsations, and may be considered to reach 16 or 17 in the minute. This relative proportion between the number of pulsations and that of the acts of respiration does not hold good for the very early or very late periods, and is liable to be disturbed by emotional causes or from diseases of the pulmonic system during any age. These computations must not be regarded as exclusively applicable to mature age, but may be considered as the general standard met with within the limits of adult age and onward to the commencement of the period of old age.

The moral and intellectual faculties at this age, although full of energy when brought into play, like the physical functions, are more passive in

their operations than at an earlier age. By the fifty-fifth year the tide in the affairs of most individuals has reached its height, and has either brought the results of good fortune or the reverse, or merely a stationary mediocrity. At any rate, the passions have become more tranquil and the emotions less vivid; the correlations of life have been established and arranged, and the duties attendant upon them are carried out and performed with coolness of judgment and steadfastness of purpose. Man becomes more conservative and selfish in his views. For the benefit of his kindred, he desires power; objects of former ambition and pleasure lose much of their interest, and his affections and energies are mainly directed toward promoting and advancing the social and material success of those allied to him by consanguinity in the general struggle of life. These intellectual characteristics of maturity, and others that might be mentioned, although indicating a comparatively passive condition, are not, however, accompanied by any diminution of susceptibility to receive in the greatest degree the injurious impressions of shock.

From this statement of the character of the vitality of the system at this period—possessing great sentiency, but lacking the protoplasmic energy of earlier years—it is evident that, gauged according to the analysis of shock heretofore given, mature age is not so favorably placed to resist and withstand the effects of severe injuries to the organization as those periods of life when there is present obtuseness of sensibility, and the recuperative forces are active.

Old Age.—Passing from the age of maturity, the sixth age is entered upon—old age—beginning at the fifty-fifth or sixtieth year and passing onward to the seventieth. It is within the limits of this age that the older writers placed the grand climacteric of life, the word climacteric being used to designate certain periods of existence which were regarded as critical. According to some authors, all those years in the life of man that are the multiples of the number seven were considered as such; others applied the term to those years only which result from the multiplication of seven by an uneven number; others admit of three climacterics only; while the multiple of nine is adopted in the reckoning by other authorities. But the importance of the sixty-third year has generally been recognized; hence it has been

denominated the grand climacteric, as that number is the product of seven multiplied by nine. These different numerical periods were adopted upon the supposition that they marked the time necessary for the entire renewal of the constituent parts of the body, so that at the termination of each period there should remain none of the elements of which the body had been composed in the preceding one. Such theories are allied to the Pythagorean doctrine of numbers; yet, however hypothetical they may be, there is no doubt that the age of sixty-three is one of much consequence in the series of septenniads through which the system has to pass. It is the turning-point at which the body begins to show signs of rapid decadence, or of the staying evidences of a vigorous constitution and of prolonged vitality. With many the indications of increasing age are for a time so slight that but little difference is discernible from that of maturity. The hair may change in color, and take on a "sable silvered" shade, yet the countenance possesses the ruddy aspect of health, the skin shows but few wrinkles, the teeth still remain, and the general functions of the body are performed with accustomed regularity. With others, however, the noiseless foot of time has already left the impress of indelible marks upon the system. The face is furrowed, the articulation imperfect, vision and the other external senses are dull, the "manly voice, turning again toward childish treble, pipes and whistles in his sound," and the "youthful hose, well saved, becomes a world too wide" for the attenuated limb. The tardy performance of the general functions of the system proclaims the declension of the physical frame. The powers of nutrition are perceptibly on the wane, and the temperature of the body is not so readily maintained at its normal height. Respiration has become more frequent, although the heart beats more slowly, yet in cases of unusual debility the pulse may be more frequent than at an earlier age. Recovery from disease and injury is less rapid. The senses, the intellectual faculties, and the moral affections participate in the general decadence of the body, and become modified to an extent corresponding with the structural changes. The first of the senses to reveal the impairment of the system is usually the sight, which at this period, with few exceptions, has begun to fail; the hearing also, in many cases, becomes measurably dull. While rationality and the judg-

ment generally remain in full vigor, the memory is less retentive. As the age of threescore and ten approaches, interest in public affairs begins to dwindle, and the sympathies to contract.

The influence of shock upon the organization at this period will differ somewhat from the effects produced at maturity or at adult age, when sentiency has not lost its acuteness nor the vitality commenced to retrograde. Although, from the dulness in receiving impressions, shock is less severe at first, yet, owing to the degeneracy of the recuperative powers, its consequences are more to be dreaded.

Decrepitude.—Extreme old age creeps on apace after the seventieth year, and although many instances are met with of constitutional vigor remaining to a much later period, yet from this time forward evidences of senility appear with unmistakable signs. Great changes take place in the general physical condition and conformation of the body, and the characteristics just traced as usually accompanying the stages of old age all become exaggerated as the succeeding years advance. In the male, the tissues become flabby and relaxed. In the female, the adipose material diminishing gives the effect of a general change of outline and appearance; the mammary glands and ovaries shrivel; hair grows on the upper lip and chin; menstruation has for a long time ceased. In either sex the hair of the head falls out, partially changes color, or becomes altogether white; and the skin is yellow, arid, and wrinkled. On account of the absorption of the alveolar processes and the retrocession of the gums, the teeth, if not already lost, soon disappear; digestion is performed more slowly; defecation is often painful and irregular, and from enlargement of the prostate gland there is often incontinence or retention of urine; the saliva is less abundant; and the bile, which is thicker, is secreted less profusely. The circulation is less rapid, the pulsation in the arteries indicating about 67 beats in the minute for the male at the age of seventy-seven, and 71 in the female; at the age of eighty-four, about 65 beats in the male, and 70 in the female. It has been asserted that the pulse in aged subjects was more frequent than in individuals less advanced in life. This statement is contrary to the results that may be daily obtained by examination. Within a week I visited a centenarian, one hun-

dred years and five days old, in whom the pulse was 56 in the minute, while the number of respirations was 30 to the minute. He is generally in good condition, conversed quite well and rationally, and contemplated going to some places of amusement in New York the day following my visit.* The lungs often become emphysematous, and loaded with carbonaceous deposits, and from their diminished elasticity, as well as from the increased rigidity of the thoracic wall, respiration is less perfectly performed, and more frequent, than at the middle ages. The capillary vessels are dilated, and more visible under the skin; the veins are larger, relaxed, and prominent, and are disposed to be varicose; the arteries are less elastic, and from atheromatous and calcareous degeneration are more resisting, and often brittle. From the diminished action of the capillaries and the modification in nutrition, the average temperature is less, and when depressed from accidental causes is not so easily restored. The eyes become presbyopic, and vision is directed and can be used to advantage only upon distant and voluminous bodies. Hearing is obtuse, and the delicate shades and cadences of sound are no longer appreciable. Taste and smell also are less acute, but seem to withstand longer the progress of time.

In very old age the brain and spinal marrow diminish in volume and density; the nervous cords are supplied with less moisture, and are atrophied. The muscles are liable to become tendinous, and the fibrous and cartilaginous structures to become in part or altogether ossified. The relative proportion of the phosphate of lime in the bones is augmented, while the organic constituents of their composition are lessened, so that they are lighter, less bulky, and more fragile.

The changes in the physical organization are followed by modifications in the mental faculties and moral characteristics. The perceptive powers are notably changed. Immediate surroundings and recent events are indifferently seized or comprehended, and badly remembered, while antecedent oc-

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* *October* 5, 1879.—The subject of this observation, Captain Denike, is a resident of the village of Yonkers, on the Hudson River, about sixteen miles from New York. He is well known as the commander for many years of a small fleet of freight sloops plying between different towns along the Hudson River and the city of New York. His sister married Paulding, one of the captors of Major André, of the British forces, taken as a spy near Tarrytown, and executed by order of Washington, 1780.

currences and knowledge acquired in times long past are vividly recollected and fondly dwelt upon. The sympathetic faculties which interest themselves in personal matters and in the affairs of the world have become languid, and the instinct leads to voluntary isolation and retirement. The merry amusements of childhood, the rollicking pleasures of youth, or the calmer enjoyments of mature age seem to remind only of days that are never to return, and no longer afford gratification. Repose and bodily comfort and freedom from noisy disturbance or intrusion constitute the main objects of their wishes. Signs of remaining *amour propre* show themselves by manifestations of gratification at the gentle caresses and attentions of children and of the surrounding members of the family. But the *morale* is often all changed, caprice, fretfulness, and uncalled-for jealousies often becoming prominent characteristics. Some of the very old, however, retain in a wonderful degree the freshness of earlier years, and exhibit the more agreeable traits of amiability and *bonhomie*. Whatever may have been the average limit to the age of man in Biblical or antediluvian epochs, the allotted period at the present time rarely extends beyond the ninety-eighth year, or the termination of the fourteenth septenniad.

As each succeeding year advances, the characteristics just mentioned become more evident and decided, and farther evidences of decrepitude become apparent: the deterioration of the muscular and nervous systems causes the body to stoop and the limbs to totter; the mind fades into "second childishness and mere oblivion." In the pre-established order of events, in the absence of unfavorable accidental causes, natural death ensues, and ends the strange, eventful history of life's brief stages, and man, having acted his part, whatever that may have been, is resolved into new elemental combinations, and disappears into the shadowy vista of the past.

The effects of shock upon the system during the period of decrepitude are likely to prove disastrous, from defective vitality. The impressibility of the nervous system has declined so far as to correspond in dulness or apathy with that of infancy or childhood; but, however indistinct the impressions may be, the reactive power is so feeble that unfavorable results are generally to be prognosticated after injuries of severity.

I have dwelt somewhat on the "influence of age upon shock," assured of the utility of bringing forward physiological details in treating of each pathological condition of the body. A revolution in therapeutics, or the management and treatment of disease, is gradually progressing; and Medicine, to become an exact science—a consummation devoutly to be wished—must be formed from an aggregate of facts collated from an accurate knowledge of the histology of the organs and the physiology of their functions, from information gathered out of the arcana of chemistry, from the localization of the nervous centres distributed throughout the various parts of the system, and the recognition of their individual uses, and from a universal acquaintance with the several organic and inorganic substances and agencies constituting the materia medica, as well as with their effects, general and special, upon the healthy and unhealthy organism, tested and administered by various methods and in modified quantities. To the knowledge thus attained must be added a familiarity with the laws of physics, with natural and mental philosophy, with anatomy, human and comparative, and with the facts obtained from the revelations of clinical observation and necroscopic examinations.

The Effect of Prior Existing Disease upon Shock.—Shock acting upon an organization already suffering from a serious disease is rendered more formidable on account of the diminished energy and ineffectiveness of the reactionary power. Shock will probably aggravate the symptoms of acute disease. Apart from the presence of evident and unmistakable disease, there may exist, more especially in one or more of the great splanchnic cavities, latent inflammations and engorgements or morbid deposits not indicated by any signs, nor apparently affecting the general health. When severe injuries occur under such conditions, if life is prolonged, and reaction takes place, the accompanying traumatic fever may excite into activity the dormant malady, producing complications that are often alarming, and not unfrequently fatal. When death occurs the autopsy reveals evident traces of previous chronic disease, which has been aroused into acute inflammatory action by the accident. Such pathological changes, concealed in the system, yet forming an important element in the intercurrent symptoms that may be developed during the early secondary effects of serious lesions, necessarily tend to involve

the prognosis in obscurity, and great care should be observed in predicting too favorable a result after severe shock. From a knowledge of such possible complications as sequences to formidable accidents, grave symptoms may be accounted for which could not otherwise be explained. For example:

Case I.—An adult male was admitted into the State Emigrants' Hospital with symptoms of stone in the bladder. His general health was tolerably good, and upon examination of the several organs no other signs of existing disease were perceptible. In sounding the bladder, a calculus was found, and extracted by the bilateral operation, using the double lithotome caché of Dupuytren, under the impression that the stone was of unusual dimensions. Nothing particular occurred at first to mar the success of the operation, the calculus being removed without difficulty. Everything progressed favorably until the fourth day, when the patient was seized with acute pain on the right side of the chest, with great difficulty of breathing and increase of fever. All the untoward symptoms continued to augment. Respiration became more frequent; the pulse rapid and smaller; the eyes suffused, glazed, and tinged with yellow; the countenance pinched, pallid, and of leaden hue; cold sweat, restlessness, delirium, hippocratic countenance, and subsultus tendinum ensued, and, finally, death occurred on the eleventh day after the operation. The autopsy showed extensive effusion of dark-colored serous fluid into the pleural cavities, with marks of the existence of former pulmonic disease, and of acute inflammatory action in the pleura pulmonalis and the subjacent pulmonary parenchyma. In this case the shock of the operation, with the consequent traumatic fever, started the lurking disease of the lungs and pleura into activity. Death was accelerated probably by the absorption of purulent material formed by the more recent unhealthy inflammatory process.

Case II.—I was consulted by a middle-aged married lady, from Maryland, suffering from a large scirrhous breast. The splanchnic organs were all apparently in a healthy condition, and the operation was performed without any unusual occurrence. The patient progressed favorably until the night following the fifth day after the removal of the tumor, when symptoms of a grave character began to appear, similar to those related in the foregoing

case. Acute pain in the chest, especially on the right side, was ushered in, with difficulty of respiration, rapid and irritable pulse, hot skin, with general febrile condition, yellowness of sclerotic, dulness on percussion, restlessness, delirium, subsultus tendinum, coma, and death on the tenth day after the operation. A post-mortem examination could not be obtained in this instance, but it is more than probable that there were scirrhous deposits in the pleural membranes and in the pulmonary parenchyma. The shock of the operation and the subsequent traumatic fever hastened the development of the morbid action in the tissues, already in a pathological condition leading to acute inflammation, with its consequences, and to effusion into the cavities of the pleura, and, finally, to the rapid and unexpected fatal result.

The influence of shock as seen upon pathological conditions pre-existing but occult is made still more evident when disease has already become marked by positive symptoms. It is not difficult to suppose that a person laboring under such an affection as Bright's disease of the kidney, diabetes, or tubercular phthisis clearly developed would suffer an aggravation of symptoms when exposed to the additional disturbing effects of a severe shock. The following cases show the effects of shock upon the system where disease previously existing was manifestly rendered more acute:

Case I.—A clergyman, about fifty years of age, had been in ill health for over a year with fatty degeneration of the heart. While lighting a match, he set fire to the bed-curtains, and in his efforts to extinguish the flame was badly burned on the hands and arms. The nervous system received a severe shock; he grew rapidly worse, and died three days after the injury.

Case II.—Not long since I was requested to see an adult male, about forty years of age, who had suffered for many months with a strumous affection of the knee-joint and tubercular disease of the lungs. The pulmonic symptoms were too evident to admit of doubt, and I was consulted merely in reference to the knee-joint, which, from neglect, presented a most destructive ulceration of all the structures composing the joint, so that the leg was attached to the thigh by little more than shreds of ligamentous and tegumentary tissue. The discharge was very profuse and offensive, and the pain excessive upon every change of position which caused motion at the joint.

The patient was anxious to be relieved from a condition so distressing, and begged to have the hurtful parts removed by amputation. I was unwilling to undertake such an undesirable task, but yielded to the earnest solicitations of himself and friends, and removed the limb by the double-flap method half way up the thigh. As far as the operation was concerned, relief was obtained from the intolerable suffering; but the pulmonic disease progressed more rapidly, and the patient, worn out by hectic, cough, and profuse expectoration, speedily succumbed.

The effects of shock may also be modified where the constitution of the blood has become perverted into an abnormal state by poisonous contamination or from psychical influences. A morbific or partially necræmic condition of the blood, produced by decomposing particles floating in the atmosphere from putrefying material, or emanating from low grades of bacterial or amœboid life pullulating in the fluids of decomposition, and inducing a zymotic process of putrefaction in others with which they come in contact, creates an adynamic state of the organization which depresses the nervous system, and which cannot favorably resist the perturbing influence of severe shock. For example: a person inhabiting an unhealthy locality, and having the blood deteriorated by prolonged exposure to a foul and infected atmosphere that engenders a predisposition to attacks of intermittent and continued fever, will not be likely to withstand shock as well as an individual in the possession of robust health. A severe shock sometimes, like the flash of lightning, destroys at once the vitality of the blood; but occasionally cases occur, which seem not very serious at first, where, from some antecedent cause, the predisposition has been created in the blood to separate into its constituent parts, and the fibrinous portion becoming disengaged from the others, leads to embolism in some part of the arterial system, and to sudden death where the obstruction happens to be in the pulmonary artery. As heretofore mentioned, when treating of the sources of sudden death after accidents, a train of moral influences may induce a similar disposition in the blood to be resolved into its general elements, so that upon the accession of a severe shock a psychical embolism may take place, with results similar to those which occur from material or physical agencies. From all this it will be seen that

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1



View of the inferior surface of the Atlas, portraying four of the fractures mentioned in the Text. Page 243.

3



Anterior view of the first cervical Vertebra (anterior surface uppermost) delineating a second view of the third, fourth and fifth fractures

5



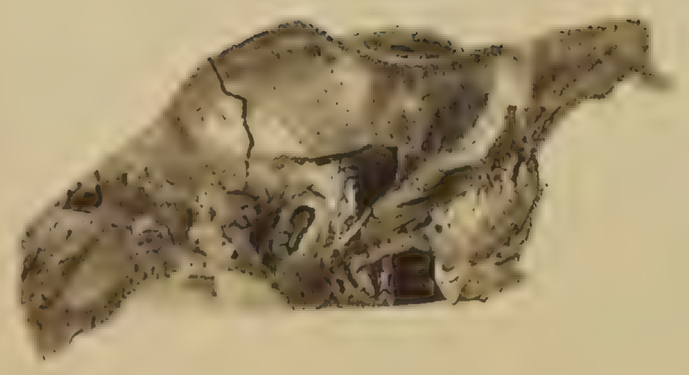
Posterior view of the third, fourth, fifth and sixth Cervical Vertebræ indicating the seat of the main fracture at the fifth Cervical Vertebra. The entire laminated process of this bone was removed at the first autopsy, and now the fragments of the body of the bone can be seen thrown back into the Calibre of the Spinal Canal, as seen also in Fig. 4.

1



Vista view along the interior of Spinal Canal, showing the degree of obliteration of the cavity of the canal by the displacement of the fragments of the body of the fifth cervical Vertebra backwards, the sixth being the proximate and the third the distal Vertebra.

2.



View of the superior surface of the right lateral articular mass of the Atlas, showing the fifth fracture of that bone

FRACTURED CERVICAL VERTEBRÆ

CASE OF E.P. CHRISTY.

where shock acts upon a system already impaired by disease or prolonged mental commotion, the danger to the patient is greatly augmented, and consequently the prognosis in such cases should be guarded.

The Relative Influence of the Locality of an Injury in Shock.—The localization of disease in the department of internal pathology has been a subject of serious study and observation by medical writers during the last two centuries. The writings of Morgani and of many of his contemporaries show the great interest taken by them in tracing out and investigating the origin and seat of medical diseases. In external pathology, however, this subject has been considered in a general way only in most of the systematic works on surgery, although the precise localizing of lesions occurring from outward agencies as a diagnostic element is correspondingly as important in the management and treatment of external injuries as in the treatment of internal disorders not originating from violence. The importance of ascertaining the seat of disease was not altogether overlooked or neglected by the early writers on medicine. Long before "the Age of Renovation," as it was called, dating from the close of the fourteenth century, Galen, and other writers following him, had given special attention to this subject, but, owing to the imperfect state of anatomical and physiological knowledge in the early and mediæval ages, as has already been remarked in relation to the symptoms of shock, it was often impossible to describe with certainty the seat of an internal disorder or of an injury received, or to limit or comprehend the resulting sympathetic influences upon the general system. Much greater accuracy has been attained and more rapid progress made in this direction during the brief period that has passed between the discovery of the circulation of the blood and the present time than had taken place during the lapse of the many centuries between the time of Hippocrates and that of Harvey. Vesalius published his great work on anatomy in 1543, supplying a more comprehensive system, and by the accuracy of his descriptions affording a new basis for the study of pathological phenomena. Fresh anatomical discoveries were soon after made by Eustachius, Fallopius, Silvius, Pacchioni, and other co-laborers, whose names thus became identified with the structure of the human body, which discoveries, by extending the

domain of anatomy, promoted especially the study of disease. The lacteals had been described by Asselli in 1622; and in 1628, little more than two and a half centuries since, Harvey enlightened the scientific world by the discovery of the circulation of the blood, designating the general mechanism by which this function is carried on, and localizing the central seat at the heart. Although this great physiological revelation was received with violent opposition by many of his professional compeers, as is not unusual upon the promulgation of any new important fact, it soon became evident to the more learned men of that day that a new era and new methods were about to commence in the study of medicine. The scientists of England, of Germany, France, Italy, and Holland, vied with each other in enlarging the field of medical knowledge by laborious investigations, and by untiring efforts to clear up the misty conceptions and crude judgments of their predecessors. Amidst a vast amount of patient and erudite research, important truths struggled slowly into light through the chaotic mysteries which still surrounded the pathways of science. In 1661, Malpighi detected the movements of the red blood globules; in 1690, Leuwenhoek, of Delft, demonstrated the capillaries. The discoveries of Vieussens, of Montpellier (1685), of Haller, of Göttingen (1736–53), of John Hunter, of London (1763), of Wrisberg, Sommering, and Willis (about 1774), of Scarpa, of Pavia (1783), and of the illustrious Morgani (1762), gave a fresh stimulus to physiological and pathological studies throughout Europe. In 1749, Senac wrote on the action and diseases of the heart; Avenbrugger, in 1761, used percussion to localize morbid affections of the chest; and later, in 1816, Laennec invented the stethoscope in order to detect the presence and limit of diseases of the lungs and of the heart. At the conclusion of the eighteenth and commencement of the nineteenth century the genius of the illustrious founder of "general anatomy" began to illuminate the scientific world. Bichat first recognized and described the separate functions of the cerebro-spinal system and of the ganglionic set of nerves, designating the former as presiding over the animal or voluntary functions, while the involuntary functions of organic life were assigned to the latter. In this discovery important revelations were foreshadowed, which were followed by results of great magnitude in relation to the fact that the nervous

system collectively was composed of a multiplicity of organs, to each of which a separate function must be assigned, instead of being considered, as heretofore, a conglomerate nervous mass possessed with uncertain and anomalous action. An equally crowning triumph of genius appeared in his original work entitled *Anatomie générale appliquée à la Physiologie et à la Médecine*, 1801, in which he simplified anatomy and physiology by reducing the mixed and complex structures of the organs to the simple and elementary tissues. These additions to science by Bichat modified radically the study of medicine and of surgery, contributed largely to the progress of pathology, and essentially to the capability of localizing disease with exactitude. For example, the different tissues of the pulmonic apparatus having been individualized, the pathological changes occurring in each become simplified and more easily understood than when thoracic affections were considered in the light of a general parenchymatous disease. The tic-tac* of the heart and the abnormal sounds of the organ in disease became more intelligible to the diagnostician when the delicate endocardiac membrane came to be regarded as a tissue separate from the subjacent cardiac muscular structure. The operation for strangulated hernia henceforward remained no longer a procedure fraught with confusion and hazard, for the greater knowledge now acquired of the characteristics of the various tissues which have to be divided in the different steps of the operation taught the operator with certainty the progress made through the several layers while guiding the incisions to reach the seat of the stricture.

Medulla Spinalis.—Of as much importance as the knowledge of the circulation of the blood, but secondary in the order of exposition, as following in the sequence of events, came the great discoveries which were made during the latter period of the last and the commencement of the present century in relation to the seat of the several functions of the cerebro-spinal system. Bichat had already, in his work on *Life and Death*, pointed out the difference between

* Lorsque, l'oreille étant appliquée sur la région précordiale, on écoute attentivement les battements du cœur, deux bruits successifs se fonts distinctement entendre, imitant assez exactement le tic-tac d'une montre, ou le double claquement d'une soupape.—Bouilland, *Traité Clinique des Maladies du Cœur.* Paris, 1841.—*Tuck-tack* and the syllables *lubb-dup* have been also suggested as conveying a notion of the two sounds of the heart, the latter by Dr. C. J. B. Williams, of Dublin.

the nervous apparatus of organic and of animal life, but the localization of the special functions of the spinal cord and nerves remained altogether unknown until the experiments of Charles Bell, corroborated by those of Magendie and of Longet, clearly proved that the roots of the spinal nerves possessed different functions at their origin, and that the medulla spinalis was composed of motor and of sensory strands and of ganglionic cells, from which emanated the nerves of motion and of sensation, by which, through their distribution, a direct communication was kept up between the different parts of the body and the encephalon. In addition to the functions of motion and of sensation thus definitely placed, Marshall Hall, following the suggestions of Prochaska, has by further experiments localized the principal seat of the reflex or excito-motor actions in the cord; and more recently an inherent independent power of control and of co-ordinating influence over certain groups of muscles in the extremities, as well as over some of the secretory glands, has also been ascribed to it. Thirty-one pairs of nerves take their origin by two roots from the medulla spinalis in the vertebral canal—the anterior roots, endowed with motion from the antero-lateral column; the posterior roots, possessing the susceptibility of sensation from the posterior column. The united fibres of these two roots, after meeting at the intervertebral ganglia situated on the posterior roots, become mixed nerves, the fibres of which, in their course of distribution, supply the several tissues of the trunk, of all the four extremities, and of the posterior segment of the head, as well as the tegumentary envelope investing those parts, by their more minute ramifications. They are also distributed directly to the genito-urinary mucous membrane, to that which lines the inferior portion of the alimentary canal, and, through the medium of the ganglions of the great sympathetic, to the whole mucous membrane of the digestive tube. The functions of the medulla spinalis and of the nerves which are its immediate appendages being definitely comprehended, it is evident that pathological manifestations denoting disturbance or total effacement of their normal actions must be referred to some morbid influence, either of traumatic or of internal origin, acting upon this portion of the nervous system. The spinal nervous apparatus is of great extent, and the character of and danger from an external injury occurring in these parts

must be estimated by considering the particular locality, the different degrees of paralysis, and the gravity of the lesion inflicted. In proportion to the intensity of the injury and its proximity to the upper part of the cord, mobility and sensibility are partially or totally destroyed, and in severe lesions of the spinal marrow immediately below the line of origin of the fifth cervical pair of nerves, total paralysis, with the exception of the nervous influence imparted by the spinal accessory and a few cervical branches, will pervade the respiratory and other muscles of the trunk, as well as those of the lower extremities, the action of the diaphragm for a time still partially sustaining the function of respiration through the medium of the phrenic nerves. These nerves, the *internal respiratory* of Charles Bell, take their origin from the third, fourth, and fifth cervical nerves, and are distributed remotely from their origin, mainly to the lower surface of the diaphragm. A severe injury, however, occurring to the spinal cord above the third cervical vertebra, such as happens from fracture with displacement or from dislocation of the superior cervical vertebræ, or from transfixion or incision between the atlas and the occiput as practised by the matadores, will be speedily followed by a fatal result, on account of the intensity of the shock, and from the apnœa which rapidly takes place from the additional suspension of diaphragmatic respiration. The case is different when the injury occurs at or immediately below the fifth cervical vertebra. Here, as just stated, respiration may be carried on partially for some time, the patient lingering out a most painful period of existence, paralyzed and entirely helpless below the seat of injury, yet still retaining intelligence and cognizance of his own and surrounding conditions, as is illustrated in the following case, to which I was called in consultation with Professor Valentine Mott and others.

Case I.—On Saturday, the 18th of July, 1857, Davis Johnson, Jun., a responsible clerk in the office of the Atlantic Mutual Insurance Company, Wall Street, received a mortal injury while bathing in the East River, at Williamsburg. In this condition of body, and in the full possession of all his mental powers, he lived a whole week, expiring on Saturday, the 25th of July, just before night. He was not quite twenty years old. There was one part of the bath-house in which the accident occurred to which, on account

of its elevation, bathers were sometimes tempted to climb for the purpose of diving, but they were forbidden to use it by printed regulations, because of possible danger. To this place young Johnson climbed, and when told by an attendant that he was doing wrong, he instantly plunged into the water. He soon rose to the surface, but his head and hands and feet hung heavily down. At first his brother, who was bathing with him, and who happened not to be in the water at the moment, thought he was sporting, as he was an expert swimmer, but perceiving that he was hurt, he hastened to his assistance. On raising his face from the water, he was told that he must carry him out, as he could not help himself. The younger brother managed to get him out of the water and up the steps of the bath-house to the platform. It is surprising that this should have been accomplished without a knowledge of the extent of Johnson's injuries, and his removal safely effected in a carriage to the residence of his parents, several blocks distant, as the slightest change in the relative position of the head and body would have been attended with great risk of death. His face was not marred, and there was no bruise on any part of the body. He said that he did not strike his head on the bottom of the bath, and this was manifestly the case, as there was no abrasion of the skin, and no pain. It was the opinion that his forehead struck the water a little at one side, and when his head and body were not in a right line with each other. The consequence was that his head was thrown violently back, and also to one side, and the cartilage uniting the bones not giving way, the sixth vertebra of the neck was literally pulled asunder, and broken into six pieces, as was afterward shown by the *post-mortem*. It was also twisted aside, so that the spinous process was quite out of line with the spinous processes of the other vertebræ of the spinal column. The pain that he felt was not great at first, and it was confined to one little spot in the neck. He could talk and move his arms at will, his respiration was easy, and his heart beat feebly, though with regularity. His body below a line crossing the chest near the nipples was dead; the process of digestion was permanently interrupted; and all sensation and all power of motion below this line were gone forever. One could puncture the flesh with a pin even without his knowledge. His arms and fingers obeyed the

dictates of his will, and retained their sensibility, though not wholly unimpaired, for at times they tingled as if "asleep," and again they were acutely sensitive, so that he could not bear to have them touched. This morbid sensibility was particularly distressing in the wrists and palms of the hands. His head was immovable, on account of the fracture of the neck, but his vocal powers and the muscles of his face were perfectly under his control, and he conversed freely with his physicians and friends. He retained his consciousness while lying perfectly helpless, and his mind seemed to be active and clear until he was struck with death. During the second day recourse was had to various means, among them electricity, with the hope of restoring the lost powers of sensation and motion to his body and legs, but without effect. His removal from the bed to a cot cost him indescribable suffering, and confirmed the judgment of the physicians that his injury must soon prove fatal. In appearance he was but little changed, and this condition lasted till the powers of life were exhausted. Had he been a youth of feeble constitution, he must have succumbed much sooner, but he had the vigor and muscular development of a much older man, and his tenacity of life prolonged and greatly aggravated his sufferings. On the Monday after the accident my old preceptor, Professor Valentine Mott, vainly tried to reduce the dislocation of the neck. Examination had at this time revealed the fact that the sixth cervical vertebra was drawn forward and sideways out of its place, but not the fact, afterward learned, that it was broken into several pieces; and as this latter fact was not known, the thought was entertained of an operation having for its object the restoration of the bone to its true place in the spinal column. The final consultation as to the expediency of an operation was held by Dr. Mott and myself with the Brooklyn physicians who had the case in charge at four o'clock on the Thursday afternoon before his death. We examined the neck and spine with great care. On being raised from a horizontal position he suffered intensely, and almost lost consciousness; the pulse went down to twelve. He rallied, however, and bore the examination with great fortitude. The paralysis was final and hopeless, and it was decided that an operation would be futile. His greatest suffering seemed to be from the inability to draw a long breath, and

the impossibility of retaining anything, even water, on the stomach. He began now to be extremely prostrated and nervous, the paralysis was constantly extending, and the sensation of internal heat was unbearable. He would insist upon a change of position, though attended with great pain, and during Friday night there was an entire inability to sleep, and the brain could get no repose. He had "sinking turns," and there were spasms of extreme sensibility in the wrists and palms of the hands, though for the most part during this last night the sensation in his arms and hands was that of numbness. It was a relief to have them rubbed with a stiff flesh-brush. Besides this there was the ever-increasing agony of difficult respiration. Paralysis was extending to the lungs and shutting out the vital air, and the sufferer was forced to distend his mouth to the utmost, gasping and panting for breath, and, still further, there was the aching of the shoulders, and acute pains in the neck so fearfully fractured. To this there was added raging thirst that could not be slaked. Ice-water was given to him at short intervals, and almost immediately rejected after he had received it. It was a terrible conflict between the vital power of a splendid constitution and death. The struggle ceased at 3 o'clock P.M. of Saturday, July 25, 1857. The *post-mortem* examination next day revealed the sixth cervical vertebra as the seat of the injury. There was a small amount of extravasated blood between the muscles, and also on the outer surface of the laminæ of the vertebra. A fracture extended on each side of the spinous process and through a large portion of the laminæ of the vertebra, constituting a separate portion, which was forced in upon the spinal cord to the depth of three-sixteenths of an inch. No blood was extravasated within the spinal canal. On opening the dura mater the cord appeared enlarged, softened, slightly discolored, and contained minute points of extravasated blood. On examining the body of the vertebra it was found to be broken through and comminuted, being divided into three separate portions. Thus it appears that the injured vertebra was broken into three principal parts, and that one at least of these three parts was comminuted, or broken into smaller pieces.

NOTE.—For the very interesting details and notes of this case I am indebted to the Rev. J. D. Wells, of Williamsburg, who was in constant attendance on the sufferer.

Examples of almost instantaneous death are met with in criminals undergoing the penalty of hanging, and in cases of fracture with displacement of the atlas and axis from other cause. If the unfortunate victim of legal retribution be strangled only, he dies from apnœa; but when from the force of the fall the odontoid process is luxated, from rupture of the transverse ligament of the atlas, it is thrust forcibly into or upon the medulla, and life becomes rapidly extinguished. The case of Johnson, just cited, is typical of the effects following injury to the spine in proximity to the fifth cervical vertebra; and in private practice, as well as in the wards of large hospitals, instances are often met with in which spinal lesions opposite the lower dorsal or lumbar vertebræ have been accompanied by transient shock only, while the patients survived for many months or years. In brief, then, the gravity of shock and collapse immediately following upon an injury to the medulla spinalis, in its extent from the atlas to the second lumbar vertebra, will in a great measure depend, other things being equal, on the locality of the lesion, the pathological effects assuming a more or less grave and persistent character according as the injury happens to be seated above or below the origin of the phrenic nerves, and whether in the cervical, dorsal, or lumbar region.

Case II.—The details of the case just related, and the symptoms presented during its progress, from the infliction of the injury to the fatal termination, were in accordance with the pathological condition of the parts as revealed by the autopsy. The following case, although almost identical in regard to the locality of the lesion of the medulla spinalis, is remarkable on account of the extent and destructive character of the injury to most of the structures entering into the formation of the cervical portion of the vertebral column and canal. The principal injury to the spinal cord was located on a level with the fifth cervical vertebra, where the cord was lacerated and almost entirely severed by a comminuted fracture and displacement of the fragments of the body and other portions of that bone. Besides this severe injury to the fifth cervical vertebra, there was a comminuted fracture of the atlas, a fracture of the fourth cervical vertebra, and a fracture of the sixth cervical vertebra. It is difficult to comprehend how such exten-

sive injuries to the different structures in proximity to the main lesion could take place without being followed by an immediate fatal result. As the patient lived from the 9th of May, 1862, until the evening of the 21st of the same month, the case must be regarded as one of those exceptional instances where, by a concatenation of circumstances, vitality does not become instantly extinguished, as might be expected—such as happened, for example, in the case of Poole, the pugilist, who lived eleven days with a bullet imbedded in his heart, simply because it lodged in the fleshy ventricular septum, and slipped under the coronary artery without wounding it or touching other important parts in its transit. The subject of this case was E. P. Christy, well known as a delineator of negro character and as the originator of negro minstrelsy. At the time his injuries occurred he was about forty-seven years of age, of good temperament, over six feet in height, and well-proportioned, married, a free-liver, and in tolerable physical health. During a successful career in his vocation he accumulated a considerable fortune, which, after his decease, became the source of litigation among his relatives. From troubles, real or imaginary, and free habits of life, his mind became unbalanced, and in a fit of insanity he threw himself from a second-story window, and alighted in the yard below, which was laid with slate flag-stone. The left posterior and lateral part of the head struck the ground first, the rest of the body, before reaching the ground, doubling up upon itself so as to throw the weight of the trunk upon the neck, breaking all the cervical vertebræ with the exception of the axis, the third, and the seventh. In addition to the above there was a large contused wound on the back of the scalp, and the left patella and right fore-arm, with some of the phalanges of the hand, were fractured. Judging from the detailed account of the primary symptoms, it is probable that the extensive fractures and the yielding of the fragments of the bones lessened the effects of the shock upon the encephalon.

During the period of his illness, from the date of the fatal leap on the 9th of May until the time of his death on the 21st, it was alleged that a testamentary document was drawn up with his assent, and signed by him, devising all his property to certain relatives, to the exclusion of others equally nearly allied to him. A suit at law was consequently brought in order to

invalidate this will, on the plea of incapacity arising from his previous mental condition, and more especially from the condition resulting from the injuries recently received. The case now assumed a medico-legal character, as well as one of pathological interest. At the coroner's inquest on the deceased the *post-mortem* examination was carried no farther than to examine the fifth cervical vertebra and the medulla spinalis on a level with it. Here the cord was found lacerated and almost severed by the displacement of the broken fragments of that bone, and as this condition was thought to be a sufficient explanation of the result, no more extended examination of the parts was at the time deemed necessary. As the legal proceedings of the case progressed, the counsel for the neglected claimants, wishing to disqualify the testimony given to prove the mental efficiency of the testator, procured an order from the court to exhume the body, for the purpose of deriving such additional evidence as might be gathered from the pathological condition of the cervical vertebræ in regard to the possibility of the continuance and exercise of ordinary intelligence after the infliction of the injuries. At this phase of the matter I became connected with the case, for the purpose of giving what is called expert testimony.

In a few moments after the fall he was picked up insensible by some of the inmates of the house, and carried into the basement, where he was laid on the floor, some blankets being placed under him. Messengers were sent in various directions to obtain medical aid, and in about half an hour after the accident the family physician arrived. The patient at this time was found to be entirely insensible, laboring under symptoms of concussion of the brain and of collapse, with feeble and rapid pulse, cold skin, and the other general signs following upon shock. In conducting the examination an extensive lacerated scalp wound was met with on the left postero-lateral part of the occipital region, a fracture of the patella, of both bones of the fore-arm above the wrist, and also a comminuted compound fracture of one of the fingers on the same side. During the dressing of the wound, and after some effort to restore the heat of the surface, partial reaction took place, and he began to make use of incoherent expressions, and was able to swallow some spoonfuls of sherry and water. At the end of an hour another physi-

cian arrived, and it was proposed to make arrangements, as he was gradually showing signs of improved circulation, to remove him from the kitchen floor upstairs to his bedroom. By the time the preparations for removal were completed he was able to talk coherently, and gave some directions as to how the change could be effected. This was done by transferring him from the floor to a board seven or eight feet in length and about two feet wide, securing him on the board by folded sheets so that he could not slip off while being carried upstairs. The head was also secured so that it could not be twisted during the different movements of the transfer. The head, arms, and body being thus suitably placed, the patient was carried upstairs by the aid of four strong persons, the head, of course, being carried first up the ascent of the stairs. From the board he was removed to the bed, and laid upon his back in a position as nearly level as possible, the head being but slightly elevated. During the first night he was conscious, partook of some fluid nourishment, and made some observations in relation to the dressing of the wounds. Soon after he was placed upon the bed his injuries were attended to as far as was necessary for the moment; the fragments of the patella were put in position, the splint upon the fore-arm, which had been casually applied, was readjusted, and light nourishment given at times. As he was unable to empty the bladder during the night, the water was drawn off by catheter toward morning.

On the second day, May 10, he rallied somewhat; pulse 100, stronger, but still feeble; took some nourishment; could speak and swallow, but upon closer investigation of the symptoms it was found that complete paralysis existed from a point below the level of the fifth cervical vertebra, with the exception of some sensation over the upper portion of the chest and the posterior part of the shoulders. There was no displacement perceptible along the line of the vertebral column. Pressure along the cervical vertebræ caused pain, but there were no special signs of fracture such as to indicate the character or extent of the injury. Not much sleep; conscious.

Sunday, May 11.—There appeared to be some improvement. He responded naturally and without hesitation to questions put to him; tone of voice as to loudness and clearness of articulation natural. The countenance

was normal, but with an anxious expression, the eyes turning about in regarding objects. Asafœtida and hyoscyamus were prescribed. The nourishment consisted of beef tea, chicken broth, ice-cream and ices of different forms, white grapes, and the juice of birds' flesh. The act of swallowing and the action of the lips in taking food were quite natural, making allowance for the recumbent position. The bowels at first were constipated, but afterward the discharges were involuntary, beginning to be so about the second or third day.

On Monday, the 12th, the circulation was better. The intelligence and senses of vision and hearing continued without apparent deterioration up to this time. He could move each shoulder in a slight degree; sensation and power of motion remained for some little distance down the back; urine became purulent, yellow in color, and offensive; alvine discharges involuntary; tympanitis; sphincters paralyzed; rattling cough; accumulation of mucous phlegm in the mouth, which, after being wiped off, would return. His condition changed for the worse. He complained of pain and chilliness, of greater difficulty of breathing; asked to have the bedclothes taken off him, and then to have them replaced. At such times the voice would be weak. There was general sleeplessness. He would drop off to sleep, and wake up suddenly. At night he would ask the nurse to lower the gas, and would slumber for ten minutes or a quarter of an hour, waking again to expectorate, when he would request the gas to be raised. He awoke easily. Placed on water-bed.

Tuesday, May 13.—He had an interview with two brothers, who visited him for the first time; recognized them, and made inquiries regarding their families; seemed to make a slight motion of the head in addressing each, as they stood on different sides of the bed; requested to have some fresh water handed to him, directing the attendant to let the water run from the faucet for some time, so as to have it cool; quite conscious, and remarks intelligent, though he was restless. Partook of ice-cream; requested his head to be changed by raising the pillow, although the change gave considerable pain. The urine had become much altered by this time—offensive, with ammoniacal odor; catheter used twice in the twelve hours, morning and evening.

From the 13th to the 16th there was but little change—no amelioration of the symptoms, but an evident increase of the difficulty of respiration, and of the trouble caused by the accumulation of saliva and of mucus in the throat and in the bronchial tubes.

Toward the 17th unfavorable symptoms developed themselves so rapidly that, in order to secure the settlement of his property, it was thought expedient to solemnize again the marriage ceremony, the legal validity of a previous one becoming a matter of doubt. The ceremony was performed on the evening of the 17th May, the patient being quite conscious, and responding intelligently. On the following day a testamentary document was read to him, to which he assented with remarks that showed he understood its import, and he then signed it in the presence of two responsible witnesses, his hand being guided, at his request.

During the 19th and 20th the unfavorable symptoms continued to advance: the eyes became more sunken, the features pinched, the countenance deadly pale, with cold sweat, restlessness, and more difficult respiration, at times gasping, mucous râle in throat, great thirst, and drowsiness. At midnight all the manifestations of approaching dissolution had progressed, and sinking rapidly from this time forward, with signs of great suffering and distress, he expired at three o'clock on the morning of the 21st.*

The cases just related illustrate well the importance of physiological study in the localization of lesions of the spinal cord, and the subordination of pathology to an accurate knowledge of normal anatomy. The symptoms in each case were entirely in unison with the nature and extent of the injuries received. In the first case, that of Johnson, the pathological condition of the parts injured was less complicated, as one vertebra only was fractured. By this fracture the cord was torn and compressed to the extent of producing loss of sensation and of voluntary motion below the seat of injury, with the exception of some parts of the upper portion of the chest and shoulders supplied by filaments from descending branches of the cervical

* NOTE.—The details of the symptoms as given above are derived mainly from the statements of Professor Charles A. Budd and the physicians in daily attendance. The *post-mortem* examinations immediately after death and after the exhumation were made by Dr. Dash and by Deputy-Coroner Dr. Bouton.

plexus, originally emanating from the cord above the lesion. Besides the phrenic nerves which lead to the diaphragm, the fourth, fifth, and sixth pairs of cervical nerves and some branches of the spinal accessory, mixed nerves in the greater part of their distribution, and connected with the cord on the encephalic side of the injury, imparted sensation and motion below the level of the line of compression, and mainly afforded the signs of sensation and motion mentioned as existing on parts above the nipples, and on the upper and posterior regions of the shoulder and back. The power of motion and of sensation remaining in the upper extremities was conveyed through the nerves coming from the brachial plexus, such as the fifth cervical nerve, which escapes from the vertebral canal between the fourth and fifth cervical vertebræ, and the sixth nerve, emanating from the cord between the fifth and sixth cervical vertebræ, both of which form part of the upper portion of the inferior cervical or brachial plexus.

In Christy's case, considering that the atlas, the fourth, the fifth, and sixth cervical vertebræ were fractured, the explanation of the symptoms as described is more complicated and difficult. Although at the second autopsy, after the exhumation, so many fractures were discovered of the several bones just mentioned, there does not appear to have been much change of position of the different fragments, as no displacement could be detected upon examination during life. Nine months elapsed before the second *post-mortem* investigation was made, and during this time the parts became considerably decomposed, so that the head separated from the atlas so easily and unexpectedly that the exact relative situation of the several fragments of the atlas escaped observation. There were five fractures in that bone, three of them with complete solution of continuity of the parts—one at the left of the posterior arch, at its junction with the mass of the articular processes; one midway between the posterior tubercle and the right articular process; two separating nearly the whole of the left half of the anterior arch, and involving slightly the left articular mass; and one involving the right articular processes and the anterior arch. The second and the last were partially fractured, without separation. The axis or second vertebra and the third were not fractured.

On the fourth vertebra there was a fracture of the left articular process, with displacement of the fragment. There was a comminuted fracture of the body of the fifth cervical vertebra, with displacement of the right half posteriorly, laterally, and superiorly, and of the left half, posteriorly and laterally, to a somewhat less extent than the right, these fragments thus displaced filling up two-thirds or more of the vertebral foramen, and encroaching on the vertebral canal so as nearly to sever all the segments or columns of the spinal cord. The spinous process and laminæ of the fifth cervical vertebra had been removed at the first autopsy; they were also fractured, and fragments of the laminæ thrust inward upon the cord. The sixth cervical vertebra was broken half-way through the body and through the spinous process along the median line, without displacement. [*Vide* Plate No. VI.]

After such extensive injuries to the atlas and the other cervical vertebræ involved, it is difficult to explain the sustained continuance of vitality and the tardy progress toward its final extinction in this case, except by the supposition that the fragments of the broken bones were mainly retained in position by the strong ligaments that connect together the different vertebræ. Even after exhumation, with the exception of the loosened attachments between the occiput and atlas, not a little force and dissection were required to separate the several bones below the atlas from each other. There is an interval between the occiput above and the atlas, and also, as the cavity of the spinal canal is large at the superior extremity, a considerable space exists between the internal surface of the atlas and the medulla spinalis within, permitting central displacement of fragments to some extent without impingement upon the surface of the cord. The case of Christy, anatomically considered, was surrounded by very unfavorable complications. The spinal cord itself opposite the atlas, although this bone was broken into five fragments, evidently escaped serious injury. The first pair of cervical nerves, passing out from the cord between the occiput and the atlas, were but little disturbed by the fracture of that bone; the second pair of nerves, that pass between the atlas and axis, would scarcely suffer, as the axis was not fractured; the third pair, that pass between the axis and third vertebra, were not involved in the injury; the fourth pair, coming out between

the third and fourth vertebræ, also escaped; the fifth pair, passing between the fourth and fifth vertebræ immediately above the seat of the principal lesion, were injured and paralyzed; and the same condition was imparted to the sixth pair, passing out from the vertebral canal between the fifth and sixth vertebræ. The sixth vertebra was fractured, but without displacement of the fragments. The injury to the spinal cord, which was all but severed through its different segments, including the gray matter and the strands, on a level with the fifth cervical vertebra, produced paralysis of voluntary motion and of sensation in every part of the body to which nerves emanating from below that portion of the cord are distributed. The natural consequence of such injuries would be a gradual deterioration of the blood from impeded respiration and defective oxygenation, and impairment of the functions of all the splanchnic organs supplied by the sympathetic nerves, which receive a certain amount of nervous influence from the medulla spinalis by means of the general connection or anastomosis which occurs between the nerves of animal and of organic life. Christy had the power of slightly moving the head laterally, which may have been partly effected by the mastoid branches of the spinal accessory nerves and by some of the deep descending branches of the cervical plexus, which take their origin above the main seat of lesion of the cord, and are distributed to the sterno-cleido-mastoid muscles, the group of small rotatory muscles passing from the occiput to the atlas and axis, and supplied by the suboccipital and other cervical branches, having lost their control from the fragmentary condition of the atlas.

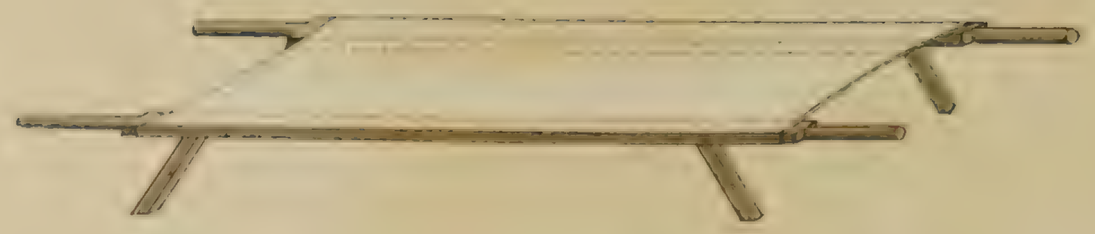
Although this case resembles that previously given, there is this marked difference to be observed, arising from the exact differential localization of the principal lesion of the cord: In the first case the injury was located in the medulla spinalis on a level with the fractured sixth cervical vertebra, the upper roots of the brachial plexus emanating from the cord, one passing through the intervertebral foramen between the fourth and fifth vertebræ, and the other through the foramen between the fifth and sixth vertebræ, escaping, and thus continuing the functions of sensation and of voluntary motion in the arm.

In the second case, that of Christy, the main lesion of the cord was opposite the fifth cervical vertebra, the fragments of which being much displaced, the fourth and the fifth cervical nerves suffered as well as the cord, so that the supply of nervous influence from the brachial plexus was entirely cut off, producing complete paralysis in the upper extremities.

In both instances, soon after the symptoms of depression and of concussion disappeared, the functions of the nerves originating from the medulla oblongata and from the base of the cerebrum were performed without great impairment. The voice, controlled by the pneumogastric, with its recurrent and other branches, and by the spinal accessory and glosso-pharyngeal, mainly taking their origin from the medulla oblongata, was not materially impaired. The ninth pair, or motor nerves of the tongue, springing from the furrow between the olivary and pyramidal bodies, supplied the tongue with motor power, as articulation was not interfered with to any extent; the third pair continued to supply the motor influence to the five muscles of the globe of the eye, as also did the sixth pair to the external ocular recti muscles; the fourth pair continued to manifest its integrity of function by the motor power remaining of the superior oblique muscles of the eye; the fifth pair, compound in its functions, supplying the muscles of the lower jaw with motor power from its smaller root, and the tongue with the sense of taste and the greater part of the face and head with general sensibility from the larger or posterior root, continued to act in a great degree unimpaired, as manifested by the ability to move the lower jaw and to appreciate the taste of articles of food or drink, as well as to take cognizance of the impressions of general sensibility. The nerves of special sense—the olfactory or first pair, the optic or second pair, and the acoustic, or portio mollis—performed their regular functions, while the portio dura of the seventh continued to perform its function, as shown by the absence of paralysis in the muscles of the face.

The most remarkable feature to be observed in both of the above cases, and one not to have been anticipated, was the disparity between the gravity of the injuries received by one of the great nervous centres, and the comparative mildness of the consecutive symptoms of the shock and collapse. From lesions of such severity inflicted upon the cord, and in such proximity

1



'S HAND-LITTER.

6

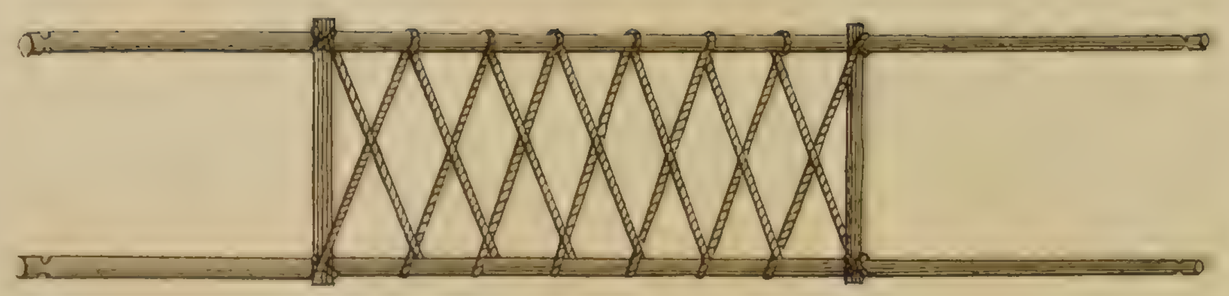


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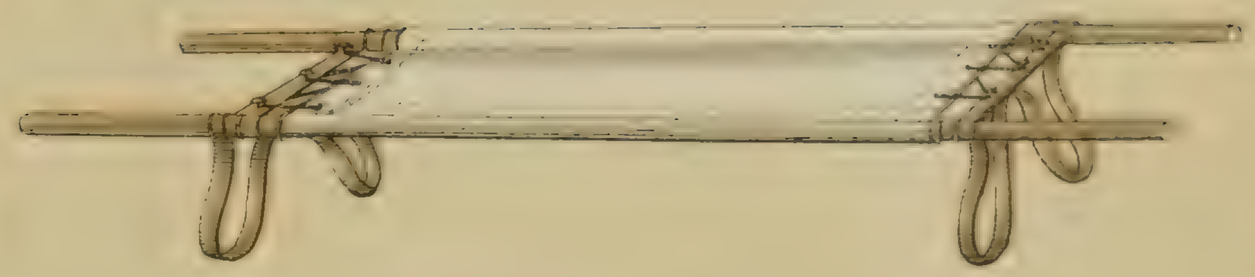


PACK HILF



SEAT MADE BY CLASPING ARMS.

1.



PRIMARY TREATMENT OF INJURIES

TRANSPORT OF WOUNDED.

Fig. 6. Represents gun shot wound of eighth, ninth and tenth dorsal Vertebræ, with a conoidal Musket ball in the Vertebral Canal, received at the battle of Cold Harbor, June 3d 1864. Soldier aged 25. The ball entered the right side of the back and penetrated the Vertebral Canal shattering the transverse and articular processes. Immediate loss of sensation and of motion below the wound. Collapse severe but not overwhelming. Reaction imperfect. Died July 2d 1864. Autopsy; Spinal cord completely severed at seat of injury and disorganized above and below.

to the encephalic portion of the cerebro-spinal axis, it was to be expected that the following collapse would be of the most overwhelming character. In the case of Johnson, however, although the injury occurred from violence and with abruptness, the patient did not even lose consciousness, but immediately called upon his brother, who was near by, for assistance. In the case of Christy there was concussion of the brain from the direct blow received upon the head on striking the ground. He remained insensible for a time, but within three hours intelligence was so far restored that he could give orders in relation to the manner of his removal to his bedroom. The several organs under the influence of the nerves originating above the seat of injury in a measure performed their functions. He could breathe, eat, drink, and swallow, and general and special sensation, with voluntary motion, remained in the structures so supplied. After the subsidence of the signs of concussion the symptoms of collapse were more persistent than severe, so that vitality waned gradually toward its ultimate extinction.

The functions of the organs above the seat of injury continued to be performed, although imperfectly; but owing to the importance of the structure involved and the irreparable character of the lesion, perfect reaction never took place, and the effects of shock upon the system at large, although comparatively light, proved in the end no less disastrous. An injury localized at the spinal nervous centre instead of toward the peripheric distribution of the nerves, as when a limb is crushed, makes a material difference in the immediate effects of shock. This fact, though heretofore not noticed, can be explained by considering that the spinal nervous system, after the manner of the arterial system, is of greater extent and of larger volume in the excentric or peripheric distribution of its trunks, branches, and ramuscules than the central parent stem of the cord from which they originally emanated. In other words, physiologically speaking, the delicate strands and nerve cells of the posterior column of the spinal cord, acting as the afferent medium of sensibility conveyed to the encephalon, embrace a much less extensive area of sentiency than the numerous fibres of the nervous trunks and branches. A greater proportion of nervous tissue being hurt in the example of the crushed limb as opposed to a case where the cord is the seat of lesion, the

nervous centres of the encephalon are more intensely impressed, and hence the shock is reverberated over the general system, is more acutely felt, and is followed by a more overwhelming collapse. Moreover, the severance of the cord itself, and the subsequent annihilation of its functions below the seat of injury, interrupt the nervous circle of sympathies, the existence and play of which are mainly essential for the production of the manifestations and symptoms of shock and collapse.

In regard to the effect of shock after grave injuries inflicted upon the medulla spinalis along the dorsal and lumbar regions, the symptoms will be modified in accordance with the relative size of the cord at the seat of lesion. As the cord increases in size in the direction of the lumbar region and toward the cauda equina, the primary influence of shock will in an equal ratio be felt more severely and more acutely by the general system; and yet if an effort of recuperation take place, other things being equal, the vitality will hold out longer, owing to the greater quantity of unaffected cineritious ganglionic matter and to the inhibitory character or conservative power of the upper section of the cord, as well as to the supply of nervous agency derived from the medulla spinalis and imparted to the organs situated in the large splanchnic cavities through the anastomosis of the great sympathetic with the spinal nerves. [*Vide* Plate VII., Fig. 6.]

Opposite the first or second lumbar vertebra the medulla spinalis splits into a number of offshoots, and forming the lash of nerves constituting the cauda equina, furnishes the several nervous trunks that enter into the formation of the lumbar and sacral plexuses. Severe injuries occurring in this direction, especially such as crush in the osseous walls of the vertebral and sacral canals so as to bruise and lacerate extensively the nervous trunks there located, will be attended by severe shock and collapse, owing to the number of internuncial afferent and efferent fibres injured, and the direct communication between them and the ganglia of the encephalon. [Plate VIII.]

Medulla Oblongata.—Anatomical nomenclature confines the medulla oblongata within a small compass, but it maintains numerous relations with different parts of the organism, and, in fact, the majority of the "nervous centres" for the regulation and performance of the various mixed organic

functions are situated in it, among which that of respiration may be considered as the most important. Besides the respiratory centre, others are localized in it by physiologists: the vaso-motor centre; the cardio-inhibitory centre; the diabetic centre, or the centre for the production of artificial diabetes; the centre for deglutition; the centre for the movements of the œsophagus and stomach, with its allied vomiting centre; the centre for reflex excitation of the secretion of the saliva, and possibly of the other digestive juices; the centre for the dilatation of the pupil by means of the cervical sympathetic; and the centre for the co-ordination of certain movements of the extremities among the mammals and other vertebrata.

The medulla oblongata is sometimes described as the link of connection between the spinal cord and the encephalon, but it should more properly be regarded as a prolongation of the medulla spinalis into the cranium, possessing a modified arrangement and distribution of the cineritious matter among the ascending medullary strands, and endowed with more varied and complex functions. In shape it is an oblong truncated conical body, of larger diameter than the adjacent spinal cord, with the base toward the pons Varolii, the smaller extremity below becoming confounded with the cord. It rests on the basilar process of the occipital bone, ascending upward and slightly forward to the extent of an inch and a quarter, and is limited in front and above by the groove which separates it from the posterior margin of the pons Varolii, and below by an imaginary line opposite the atlas, and immediately below the place of decussation of the pyramids. In performing an experiment upon the cadaver, however, the relations of the inferior portion of the medulla oblongata changing according as the head is placed in a right line with the body or in a position of flexion or extension, a cutting instrument passed between the atlas and occiput will divide the rachidian bulb at a point varying in accordance with the difference of attitude maintained at the moment.

The bulb superficially may be regarded as having four aspects or surfaces—an anterior, a posterior, and two lateral. After removing the pia mater from the *anterior* surface, a median fissure is seen continuous below with the anterior median fissure of the spinal cord, and presenting above, at

the posterior border of the pons, a small triangular fossa, called the foramen cœcum. Here delicate vascular ramifications penetrate into the median fissure, at the bottom of which appears a thin commissural medullary layer, perforated for the transmission of small vessels. On each side of the median fissure two oblong projections are seen—the anterior pyramids; outside of these, and somewhat behind, are found two ovoid eminences—the olivary bodies. The pyramids and the olivaries are separated by furrows, which are continuous with the antero-lateral grooves of the medulla spinalis. Frequently a part of the anterior surface of the bulb is sparsely covered by scattered transverse fibres, which, taken collectively, are called by some anatomists the ponticale, or little pons. The pyramids, occupying the entire length of the medulla oblongata, are contracted below, become larger in the middle, and again contract before their entrance below the transverse fibres of the pons Varolii. Along the bottom of the groove which separates the pyramids from the corresponding olives, the radical fibres of the hypoglossal, or ninth pair of nerves, are seen to take their emergence. The two olivary bodies are situated to the outside and somewhat behind the two pyramids, and pass forward a little obliquely from below upward. They form on each side a rounded and oblong eminence, very consistent, and white on the exterior. A small space at the upper and outer extremity of each olive, called the fossa of the olivary eminence, separates it from the annular protuberance, and from which the facial nerve, or motor nerve of the face, is seen to emerge.

The *posterior* surface of the bulb superiorly runs continuously into the upper surface of the pons, and can in this direction be limited only by a fictitious line carried backward transversely from the anterior line which separates the bulb from the pons in front. In its lower half it is completely overlapped and embraced in a large and deep depression which the circumference of the cerebellum presents. At the inferior border, the medulla oblongata is rounded like the posterior part of the cord, and terminates, without any line of demarcation, immediately below the calamus scriptorius and the place of decussation of the anterior pyramids. The posterior columns of the medulla spinalis ascend along the postero-lateral part of the bulb toward the cerebellum and cerebrum, and in their course form the restiform

bodies. These rounded eminences extend laterally on each side from the posterior median fissure to the postero-lateral spinal grooves. By a superficial groove each is subdivided on both sides into two secondary cords. Those next to the median fissure present two slender longitudinal prominences, named the posterior pyramids, that pass upward from the medulla spinalis, and after forming two mammillary projections at the point of the calamus scriptorius, diverge, and are lost near the lateral angles of the fourth ventricle. Outside of these posterior pyramids the rounded eminences of the restiform bodies properly so called are seen diverging above, so as to form the lateral boundary of the lower triangle of the fourth ventricle.

The fourth ventricle, or ventricle of the cerebellum, is located partly behind the bulb, and partly on the posterior surface of the pons Varolii. It is about an inch and a half in length, and the same in breadth at its widest part, and is lozenge or diamond shaped, with the points vertically and laterally directed, thus giving the idea of an upper and lower triangle. From the apex of the calamus scriptorius, and from the entrance of the aqueduct of Sylvius, the angles of the lozenge-shaped figure pass outward into the cerebellum, and divide the ventricle into two triangles, the lower of which has the base at the upper limit of the bulb, while the apex is formed by the nib of the calamus. The upper triangle has its base also at the upper part of the bulb, the apex resting at the entrance of the aqueduct. The anterior wall is thus formed by the posterior surface of the medulla oblongata and of the lower part of the pons. The posterior wall of the ventricle is formed by the valve of Vieussens and the processus a cerebello ad testes, by the middle lobe of the cerebellum, by the uvula and nodulus, and partly by the amygdalæ, or tonsils, which lie on either side, and by the inferior medullary velum. The sides of the ventricle are the lines of junction between the anterior and posterior walls, and are formed by the white central nuclei of the cerebellar hemispheres. Besides a delicate lining membrane, the greater part of the ventricle is coated with gray neurine matter, which is continued from that of the cord. On each side of the vertical median furrow in the lower triangular space are seen numerous white striæ, generally transverse, and variable in number. Some of these concur to form the origin of the

portio mollis. A larger quantity of the cineritious matter exists around the striæ, and probably serves as a ganglionic centre to the auditory nerve. Below the point of the triangular gray depression which forms the lower part of the fourth ventricle, and immediately below the point of decussation of the anterior pyramids, the medulla oblongata posteriorly is rounded like the posterior part of the cord, and there its inferior limit posteriorly is located, without any definite line of separation.

The *lateral* aspect of the bulb presents objects of no less importance. The anterior pyramids and the olivary bodies already mentioned as found on the anterior aspect are also partly seen here, with the groove which courses between them. Besides these, the intermediate fasciculus of Rolando appears situated between the olive and the line which is a continuation upward of the postero-lateral furrow of the cord, and from which at its upper part emerge the radical fibres of the glosso-pharyngeal and the pneumogastric nerves. This fasciculus, which Charles Bell named the respiratory fasciculus of the bulb, is the prolongation of the anterior and part of the lateral column of the cord. On each side of the bulb, and about three or four lines below and behind the olivary body, an elevated prolongation seven or eight lines in length and a line in depth is seen bulging from the postero-lateral line, which Rolando has designated as the *tubercule cendré*, and which is described by him as formed by an increase of development at this part of the cineritious or gray matter of the cord enclosed in the medulla spinalis, and which can be traced upward through the bulb as far as the fourth ventricle. This projection is not always distinct or well marked. A series of medullary fibres are at times met with, apparently springing from the transverse fibres of the pons Varolii behind the olives, and which, curving upward, are directed forward so as to open and spread over these eminences and the pyramids, and which extend as far as the anterior median fissure, into which they sink, and are there lost. These arciform fibres, as they are called, become aggregated in some cases into two fasciculi, one of which passes around the superior extremity of the olivary body and pyramid; the other partly encircles the olivary body inferiorly, and forms what has been named by Gall and others the *processus arciforme*, both fasciculi ultimately termi-

nating in the median fissure, and representing in a manner transverse bands uniting the strands of the vertical fibres of the bulb.

Structure of the Medulla Oblongata.—An accurate knowledge of the structure of the medulla oblongata gives the key to the study of the physiology and pathology of the encephalon. It is here that the decussation of the anterior pyramids is met with—a feature of great importance, still affording a subject for diversity of opinion and for scientific controversy. Besides being a ganglionic centre communicating with many parts of the system, several of the most important nerves of animal life are connected with it: the ninth pair, emerging from the groove between the pyramids and the olives; the eighth pair, pneumogastric, glosso-pharyngeal, and spinal accessory, between the olives and the restiform bodies; the auditory, by the side of the calamus, from the olivary columns; the sixth pair, between the upper part of the anterior pyramids and the pons. The roots of the fifth pair can be traced into the olivary tracts; and the radical fibres of the portio dura, taking their origin below the crus cerebelli, behind and above the olivary body, and in front of the restiform body, in their course send fibres here into the gray neurine, and are thus brought into correlation with the roots of the fifth pair. Moreover, it is in this segment of the cerebro-spinal axis that the seat of vitality, the *nœud vital* of Flourens, is localized by physiological experimentation and pathological observation, and that the superior, middle, and inferior cerebellar peduncles form the bond of connection between the bulb, the cerebellum, and the ganglia of the cerebrum.

Several grooves and lines present themselves successively from before backward on the surface of the medulla oblongata, which claim attention by serving as landmarks for description, and for localizing the several structures and the morbid conditions by which they are at times affected. Behind the margin of the anterior median fissure, separating the medulla into two lateral halves opposite the pyramids, the line of demarcation between the pyramids and the olives—the continuation of the antero-lateral groove of the medulla spinalis—is seen. At the lower part of the pyramids this groove bifurcates, so as to surround the outer border of the olivary body as far as the lower border of the pons, near the place of emergence of the portio dura and portio

mollis nerves. Behind this line the intermediate fasciculus of Rolando is seen, bounded posteriorly by the continuation of the postero-lateral groove of the spinal cord. Posterior to this groove is located the restiform body, which is separated into two portions by another groove coursing along the outer margin of the posterior pyramid. On the inner margin of the posterior pyramid is seen the posterior median fissure, dividing the bulb into two equal parts. Below and behind the lower part of the olivary body, and on the tract of the postero-lateral groove, may be found in some instances the superficial furrows circumscribing the *corps cendré* of Rolando, which is here seen bulging outward opposite the posterior horns of the gray matter situated in the interior of the medulla.

Decussation of the Fibres of the Bulb.—A knowledge of the manner of the *decussation of the pyramids*, and of the intercrossing of the medullary fibres at different heights in their transit from the medulla spinalis and the cerebellar peduncles toward the encephalic ganglia, and the course and direction of those fibres that do not cross from one side of the encephalon to the other, is of much importance in regard to the election of the place for operations which are sometimes required in the primary treatment and management of certain injuries of the head, as well as in the conduct of the more chronic cases, such as unilateral epilepsy occurring from supposed cerebral compression and irritation. Thus, for instance, as in the following case, which came under my observation:

Case.—A patient was brought into hospital who had been thrown from his carriage, and received such injuries to the head as pointed out the existence of concussion and of compression of the brain. The skin was cold and clammy; there was general insensibility, with jactitation at times; the pupil contracted on one side and dilated on the other; the pulse, frequent at first, gradually became slower; the respiration, from being irregular and frequent, became by degrees slower and stertorous; the limbs abated their restlessness, and showed gradual signs of complete paralysis, with turgid countenance and puffing respiration. In the course of some hours the pulse became fuller, beating from forty to fifty to the minute. While the signs of concussion wore off, those of compression became more aggravated; and yet with all

these symptoms there was no evident fracture of the cranium, nor sufficient contusion to indicate the exact site of the encephalic lesion. The left pupil remained more dilated than the right, and the left side manifested somewhat sooner than the other the signs of complete paralysis. What could have occurred here? Was it extensive laceration of the encephalic structure? or might it not be a rupture of the middle meningeal artery as it courses along the anterior inferior angle of the parietal bone, followed by extensive effusion of blood, of compressing quantity, extravasated between the dura mater and the internal wall of the cranium? The day after the occurrence of the accident, the symptoms of compression still continuing, and vitality showing signs of failure, it was considered advisable to accept the diagnosis ascribing, from the nature of the injury and the manner of the inauguration of the symptoms, the paralysis to extravasation of blood from the middle meningeal artery, and locating the main seat of the cerebral compression upon the right side of the brain. The crown of a trephine was applied at a point opposite the anterior inferior angle of the parietal bone on this side, and a disk of bone removed. Immediately under the removed bone a thick layer of coagulated blood was met with. Upon the removal with the trephine of another disk of bone, the extravasation was found to extend over a large portion of the side of the right hemisphere. A portion of the coagulum was removed by a curette, and a stream of tepid water thrown in between the cranium and the dura mater, with the expectation of detaching and removing the remaining portion of the stratum of coagulum; but this could not be entirely effected, so great was the extent of the effusion. The wound was dressed in the ordinary way, by approximating the edges of the flaps and maintaining them by suture in apposition, and applying a wet compress and retentive bandage. The diagnostic ratiocinations proved to be correct, but the patient was not relieved by the operation, and succumbed from the effects of the shock and the severity of the injury the next day after its performance. The *post-mortem* showed that the artery supposed to be the source of the compression was lacerated, and that three-fourths of the surface of the right hemisphere was covered by a dense layer of coagulated blood. In this case the main seat of the lesion was partly indicated by the marks of con-

tusion, by the condition of the pupil, and by the earlier manifestations of the advancing paralysis upon the lower extremity of the left side.

It is a matter of frequent occurrence to find a patient paralyzed upon one side from some pathological cause present upon the opposite side of the encephalon. The ancient medical writers tried to explain this fact by the intercrossing which was supposed to exist among the encephalic fibres, or in the radicles of the nerves. The decussation of the pyramids, however, was not really discovered and described until 1709, when Dominique Mistichelli, in his *Trattato dell' Apoplessia*, gave publicity to the important anatomical fact that the medullary fibres immediately above the neck of the rachidian bulb traversed obliquely upward and across the median line, and decussated in such manner that those upon the right side passed to the left, and those upon the left side passed to the right. In the following year, Pourfour du Petit published the same discovery in France, as follows: "Chaque corps pyramidal se divise à sa partie inférieure en deux grosses manipules de fibres, le plus souvent en trois, et quelquefois en quatre. Celles du côté droit passent au côté gauche, et celles du côté gauche passent au côté droit, en s'engageant les unes entre les autres." Many celebrated authors, among whom may be mentioned Morgagni, Haller, and Chaussier, refused to admit the assertion of the Italian anatomist in regard to the interlacing and decussation of the nervous filaments of the pyramids at the point indicated. Thus Chaussier writes: "On peut faire voir, à ceux qui se contentent de l'apparence, des espèces de cordons mous, blanchâtres, qui se dirigent dans le fond des sillons longitudinaux, et semblent se porter transversalement d'un côté à l'autre; mais, en examinant les objets de plus près, il nous a paru que ces prétendus faisceaux de fibres transversales ou obliques sont uniquement le résultat de la traction, que l'on exerce sur le tissu de la partie, qui, avant de se déchirer, s'allonge, et prend l'apparence fibreuse."* About the same time, Gall, in a memoir presented to the French Institute in 1808, described at length the decussation of the pyramids, asserting the complete interlacing from side to side of certain medullary fibres of

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* *Exposition Sommaire de la Structure de l'Encéphale.* Paris, 1807.

the bulb, and claiming that he had by his description placed the matter beyond doubt, and so rendered useless farther discussion as to the incontestable fact. Translated, Gall's statement was as follows: "About an inch and some lines below the *annular protuberance*, there can be seen a small trestle-work [*tresse*], formed by from three to five cords interlaced, and which are directed obliquely from below upward, and occupy a space of nearly three or four lines in extent. The nervous fibrils which take their origin in the gray substance on each side are at first reunited into little cords, and these cords cross one another, to pass over to the other side.....Having demonstrated the reality of the intercrossing, and by indicating at the same time the preparations necessary to be used for all those who desire to be convinced, we flatter ourselves that we have put an end for all time [*pour toujours*] to any farther discussions on the subject."*

The memoir of Gall, who was then pursuing his investigations on the brain with Spurzheim, was favorably noticed by Cuvier, and his views approved in his report to the Institute. Still, so far but little was added to the discovery made by Mistichelli upon the decussation of the pyramids. Since the writings of Gall, different anatomists have elucidated certain points in connection with the structure of the rachidian bulb, among whom may be mentioned Longet, Vulpian, Flourens, Foville, and, more recently, M. Sappey and Matthias Duval. It is comparatively an easy task to establish the course of the strands or cords of the medulla spinalis and the fibres of which they are constituted, and the same may be said of the fibres of the pons Varolii, and of the peduncles of the cerebrum. In regard to the rachidian bulb, however, and the structures which unite the bulb to the cerebellum and cerebrum, the inclination, the change of direction, the irregularity and disassociation, and the intercrossing of the fibres, are such that it becomes a matter of great difficulty to arrive at a precise comprehension of the disposition of the nervous fibres. This very difficulty makes it the more important to acquire an intimate knowledge of the structure of the bulb, as without such knowledge it is impossible to understand many of the symptoms and

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* *Recherches sur le Système Nerveux en Général.* Mémoire présenté à l'Institut, Mars, 1808. Paris.

manifestations which occur in the system after severe shock and the collapse which follows.

The internal structure of the bulb is made up of the prolongation upward of the several strands of the medulla spinalis, and of the cineritious matter, which is also continued upward and forward in a modified shape and arrangement. In the bulb the gray matter is named the corpus dentatum, and forms one part of the chain of ganglionic cineritious masses situated along the inferior and central portion of the encephalon, and extending anteriorly as far as and into the corpus striatum. The rachidian bulb is the link of connection between the medulla spinalis and the cerebrum through the medium of the fibres of the pons Varolii and of the peduncles of the cerebrum. It also serves as the bond of union between the cerebellum and the cerebrum by means of the fibres of the posterior column of the medulla oblongata, which, under the name of the corpus restiforme, pass outward and backward to the centre of the cerebellum, while another set of fibres, starting from the corpus rhomboideum, or central cerebellar ganglion, pass forward and inward, and form the superior peduncles of the cerebellum, or the processus a cerebello ad testes. Commencing at the gray mass or corpus dentatum of the bulb, and passing from behind forward, the ganglia at the base of the brain will be found placed in succession as follows: the ganglia of the mesocephale and the *locus niger* of each crus cerebri; the cineritious matter of the corpora quadrigemina and of the optic thalamus (*noyau* of Stilling); and the gray matter (*noyau caudé et noyau lenticulaire*) of the corpus striatum. The corpus rhomboideum, or internal cerebellar ganglion, has already been mentioned as being in direct communion with the cerebrum through the fibres of the superior peduncles of the cerebellum. These ganglia at the base of the brain, taken collectively, constitute the *ganglia of re-enforcement* of Gall, and are placed, with the exception of the lenticular nucleus, within the limits of the internal capsule of Burdach, Charcot, and other writers on cerebral localization. Farther on, and remote from the basilary ganglia, the gray matter of the cerebral convolutions and that of the laminated cineritious plates of the cerebellum compose the limits of the encephalon. Among these nuclei of generative cineritious nervous matter the white or

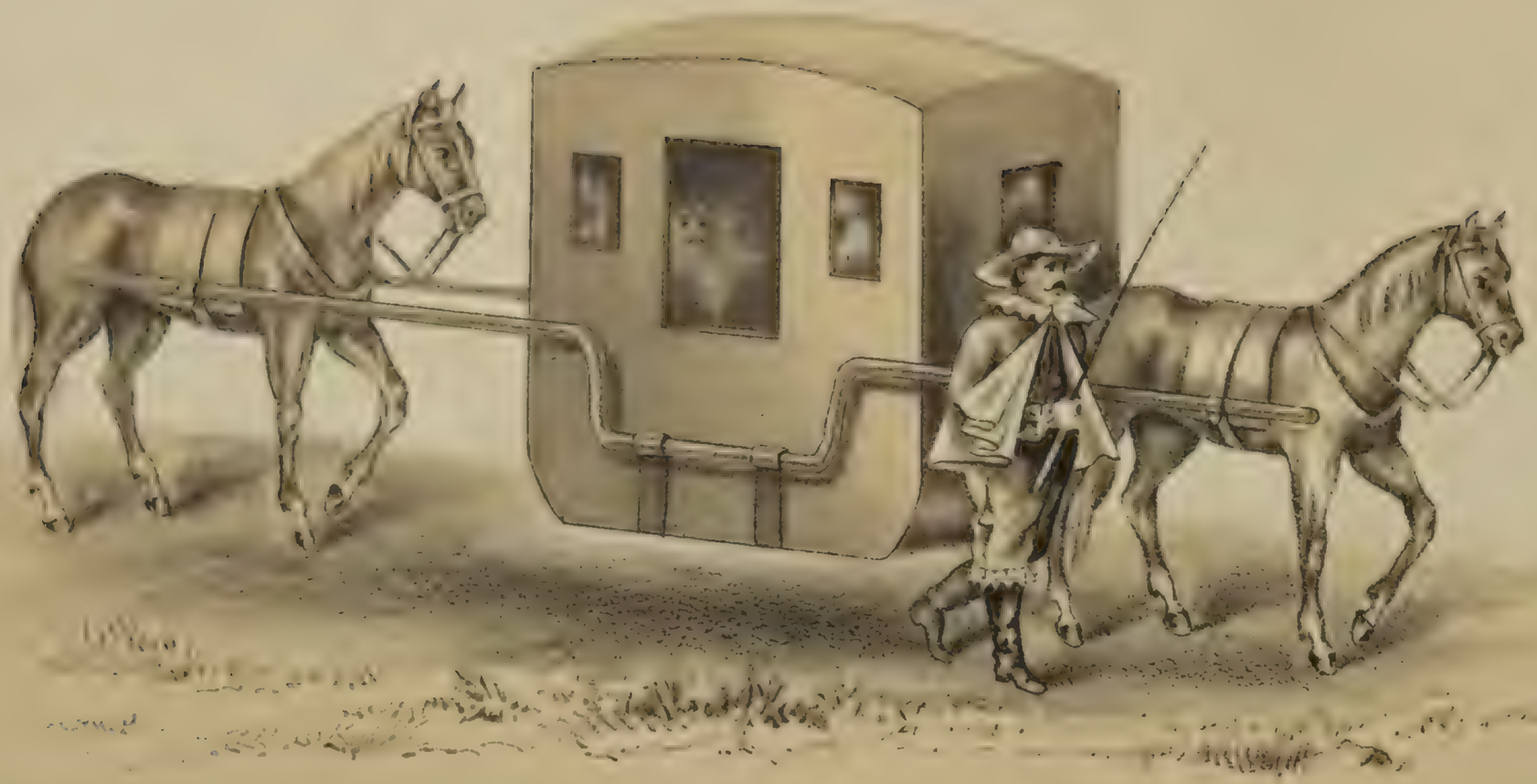
medullary fibres take their forward course, and on entering the inferior cerebral ganglia separate, and intermingle with the cineritious neurine. Some of these fibres seem to terminate there, while others appear to take their origin from the gray matter, apparently intercrossing, and assuming a plexiform character. The white fibres at times have the appearance of increasing in size as they advance, and some of them can be traced successively into and through the cineritious matter of the optic thalami and corpora striata, beyond which they send off numerous fasciculi that radiate in various directions, and ultimately form the greater part of each cerebral hemisphere, one portion of these fibres passing upward to enter into the formation of the inferior lamina of the corpus callosum. The fibres emerging from the anterior and inferior portion of each crus cerebri run more directly through the corpus striatum. They are made up in part by the prolongation of the antero-lateral fibres of the cord, or of the motor portion, and are thus continuous with the anterior pyramids. These fibres, mentioned as passing from behind forward for the sake of description, are considered by some writers as descending from the gray hemispheric convolutions, and as constituting the nervous fibrils along which volition is entirely or chiefly transmitted, while the function of volition is supposed to have its source in the gray substance of the convolutions, and perhaps of the corpus striatum, and in its action to pass along the decussating bands of the pyramids, mainly to the opposite spinal motor tract, and thus to the anterior or motor nerves of the opposite side of the system. The posterior and superior portion of each crus cerebri contains fibres that pass forward through the optic thalami and corpora striata, and are in direct continuity with the postero-lateral portions of the medulla oblongata, where sentient and motor fibres and cells are situated. The fibres thus radiating toward the cerebral convolutions may be regarded as ascending fibres, along which external and internal impressions are conveyed to the superficial cerebral ganglia, where perception is situated and volition has its origin. Whether the medullary fibres which thus traverse successively from below upward through the several cerebral cineritious masses end partly in them, or pass through them to the hemispherical ganglia, or terminate in loops or plexuses, and are

merely capped by the cerebral convolutions, or are continuous with the descending motor tracts, are points that still afford a field for anatomical research. However the problem as to the ultimate physical relation between the white medullary fibres and the gray cineritious matter of the convolutions may be solved, it has been ascertained by experiment that there is a continuity of function between these different structures, and that there are sensory and motor fibres passing from below upward that are continuous with the sensory and motor strands of the *medulla spinalis*, and that these fibres traverse the basilar cineritious masses or ganglia of the encephalon, from which fresh functional power is derived. Moreover, in confirmation of this view, the analogy of function and of origin of the cranial and spinal nerves is maintained throughout the cerebro-spinal system, for the cranial nerves take their origin in proximity to the white medullary fibres or to the nuclei of gray matter in accordance with their individual functions, the sensory cranial nerves taking their radical or real origin among the sensory fibres and nerve cells, and the motor nerves in immediate connection with the motor tract. This correspondence of origin and of function is carried out even with the nerves of mixed character—such as the fifth pair, with its sensory and motor roots; the seventh pair, embracing the facial and the auditory nerves; and the eighth pair, including the glosso-pharyngeal, the par vagum, and the spinal accessory. The radicles of these compound nerves are found to be connected with the sensory or motor fibres and cells in accordance with their mixed functional character.

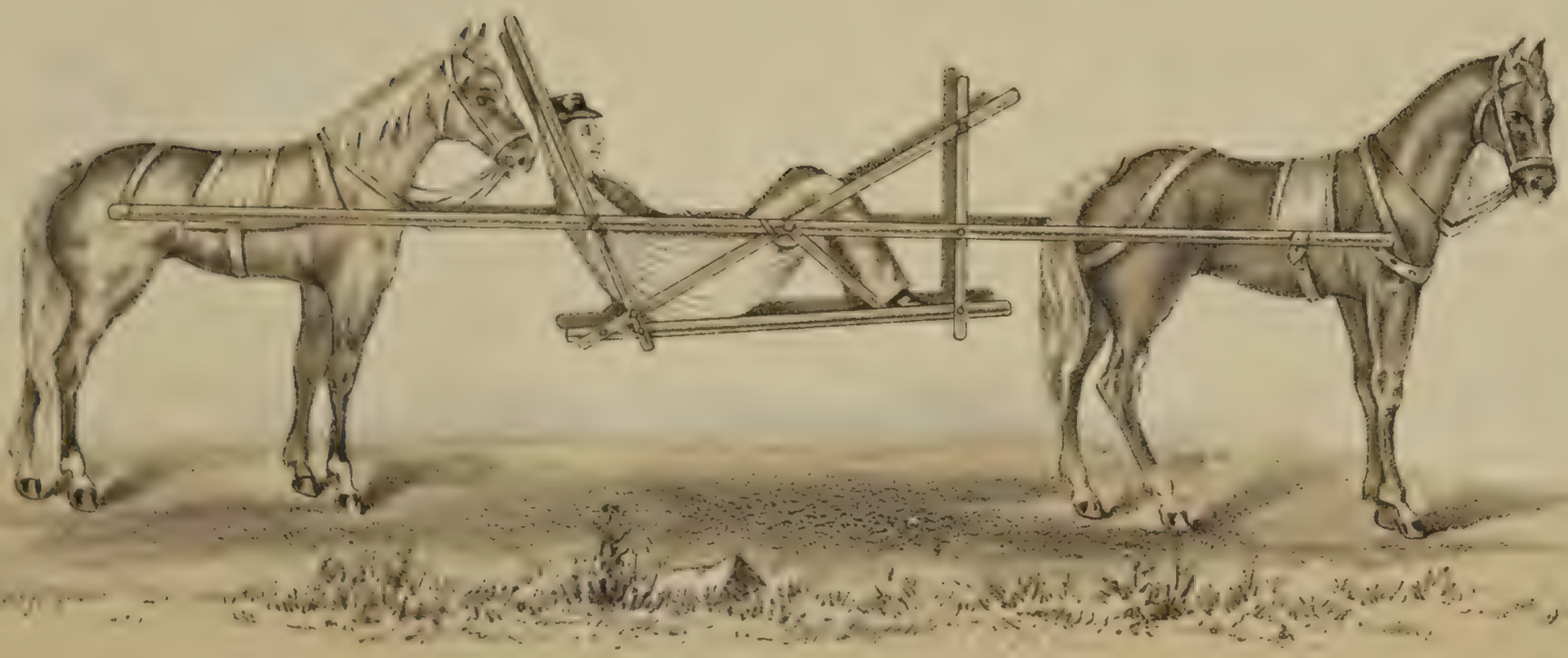
Besides the medullary fibres and cineritious matter mentioned as contributing to carry on the several cerebral functions just enumerated, other small aggregations of nerve cells are met with, and sets of fibres are described as originating in and descending from the gray matter covering the convolutions and lining the intervening sulci of the cerebral hemispheres. These fibres, converging at different points, pass toward the mesial line, and in this manner the great cerebral commissure, or corpus callosum, and the anterior and posterior commissures, are supposed to be formed. The hem-like convolution, or *ourlet;* the hippocampus, major and minor; the fornix; the tænia semicircularis of Haller; the pineal gland and its peduncles; the infun-

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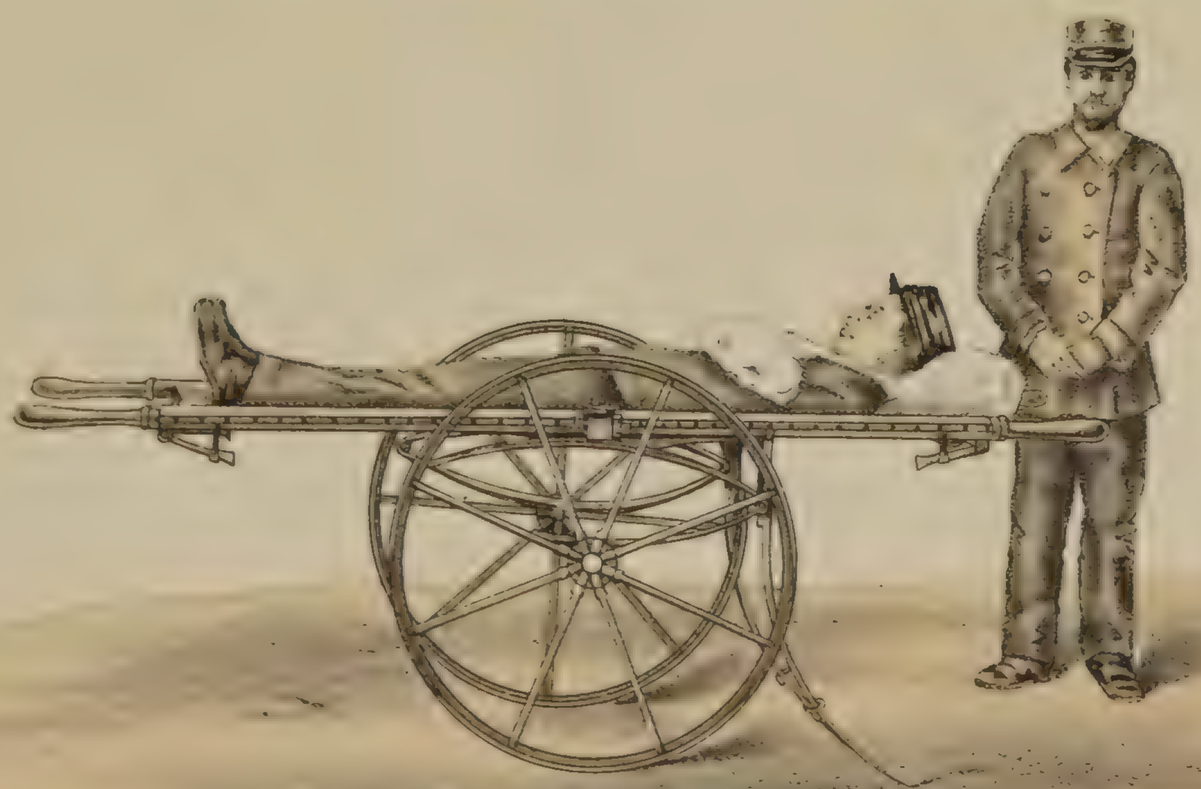
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Julius Bien & Co. lith

PRIMARY TREATMENT OF INJURIES

TRANSPORT OF WOUNDED.

№1 Two-Horse Litter of the XVI Century. №2 Horse Litter_Lord & Baines №3 Wheeled Stretcher_Longmore.

dibulum; the septum lucidum; the valve of Vieussens; the *velum medullare inferius* of Reil; the velum medullare posterius, or valvula Tarini; the optic commissure, or chiasma—in conjunction with numerous arciform and irregular fibres and cells, serve as media of communication between different parts in each cerebral and cerebellar hemisphere, and as links of association of the several portions of the nervous centres with each other. Thus four species of fibres, terminating most probably among the cellules of the gray substance, are here met with—commissural fibres, arciform fibres or fibres of association, peduncular fibres, and those which radiate toward the periphery. This digression from the consideration of the structure of the rachidian bulb to the anatomical details of the other parts of the isthmus of the encephalon—that is, of the pons Varolii, the crura cerebri, the crura cerebelli, the tubercula quadrigemina, the optic thalami, and the corpora striata—seemed to be necessary in tracing the continuity of the fibres of the medulla spinalis and medulla oblongata toward their points of decussation, as well as on account of the intimate connection and relation of these several parts of the nervous centres, and of the bearing they have in shaping the character of the symptoms of nervous shock and collapse after certain severe injuries. The decussation of the descending and ascending medullary fibres at the pyramids and at other points toward the periphery can now be reverted to; and the influence of this peculiar arrangement of the structure in relation to the localization and symptomatology of cerebral disease, whether resulting from internal causes or from external injury, will be more easily comprehended.

The internal structural complexity, the source of the difficulties that attend the study of cerebral pathology, vaguely described until recently, becomes increased at the neck of the bulb, and continues along the course and distribution of the medullary fibres of the motor and sensory tracks. The anatomical obscurity which has rendered descriptions of cerebral disease inexact, although gradually lessening, is still great, and will require careful and minute research to overcome. The system inaugurated by Waller of following by microscopical observations the progress of nervous degenerations which result from section or lesion of the different kinds of

nerves, and of different portions of the medulla spinalis and of the cortical substance of the convolutions, applied to the study of the pathology of the cerebro-spinal axis, and the more careful and exact examination of the situation and limits of lesion after death, in correlation with the symptoms manifested during life, will probably lead to results more precise in their character than could be obtained by the methods ordinarily used in cerebral experimentation. In the present state of knowledge, a source of diagnostic complexity arises from the fact that many of the cranial sentient nerves take their real origin in proximity to the gray cerebral matter from which also emanate the radicle fibres that pass toward and ultimately are distributed to the muscles of voluntary motion, as is exemplified by the different classes of nerves that spring from the floor of the fourth ventricle. The intricacies that are encountered in localizing cerebral injuries are illustrated by the different forms of paralysis which occur from cerebral alteration of structure. Thus a cerebral lesion may not be accompanied at all by paralysis, either of motion or of sensation; or there may be a paralysis of motion on the same side as that on which the lesion has taken place; or the motor paralysis may be on the side opposite to that where the lesion is present; or there may be an alternate paralysis when a cerebral lesion occurs at a place where a motor cranial nerve is affected, and there is also an injury to a portion of the cerebral structure above the decussation at the medulla oblongata (in such case the paralysis of the cranial nerve will be manifested by loss of power on the same side as the lesion, while the opposite side of the body will suffer from loss of motion from the injury to the cerebral tissue); and again, there may be partial paralysis only in cases where the lesion of a nerve does not extend beyond the limits of its origin. These varieties of motor paralysis may be analyzed and explained anatomically. Thus the fibres composing the transverse medullary planes or layers of the pons Varolii emanating from the middle cerebellar peduncle have no action or influence upon any of the voluntary motions; consequently if these planes alone become the seat of lesion, there will be no paralysis of motion.

The paralysis will be direct—that is, upon the same side as the lesion—if the injury is located on the prolongation of the *lateral fasciculus* of the

medulla spinalis which reaches the pons Varolii without having undergone decussation, at the pyramids of the bulb.

The majority of cases of encephalic paralysis will be of a crossed character, because the vertical fasciculi passing from the medulla spinalis in their progress toward the basilar ganglia are more numerous and decussate in the region of the medulla oblongata.

An example of alternate paralysis is met with when there is a lesion of one of the halves of the pons Varolii, implicating the facial or motor nerve of the face, or its apparent origin, situated at the point of union of the protuberance with the bulb. If a hemorrhagic clot exist implicating the facial nerve in the right half of the pons there will be facial paralysis of the same side, because the nerve of the right side is compressed or destroyed by the lesion, while there will be a loss of voluntary motion on the left side, because many of the fasciculi of the right side of the protuberance pass to the left at the bulb and vivify the muscles on the left side of the body.

There may occur also merely a partial paralysis, as takes place sometimes in the face, or in the motor muscles of the globe of the eye, when the trunks or real origins of the nerves are alone implicated, the cerebral structure retaining its integrity.

To continue this illustration: A lesion of the cerebral peduncle may give rise to a paralysis of the third or common motor of the eye, and of the fourth pair or the motor of the superior oblique muscle of the eye, if the radicle fibres of these nerves are affected. Also, as a part of the radicles of the third pair spring directly from the gray substance of the cerebral peduncles, a peduncular lesion may produce an alternate paralysis; in other words, from a lesion of the right peduncle, a hemiplegia of the left side, and a paralysis of the ocular muscles animated by the third pair upon the right side, or upon the same side as the lesion, may be the result.

The following instance of facial and of auditory paralysis came under my observation some time since, which is a type of direct unilateral paralysis of the motor and sensory functions occurring simultaneously from cerebral lesion upon the same side:

Case.—A male patient, about middle age, was presented to me to render

a diagnosis of his condition, the principal symptoms being marked by an absolute paralysis of motion of the muscles of the left side of the face, accompanied by entire loss of hearing on the same side. There was no hemiplegia or general paralysis. The upper eyelid drooped; the cheek was flaccid and motionless; the angles of the mouth were twisted and turned toward the right side, and labial articulation impeded and indistinct. General sensation, vision, and the control of the motor muscles of the globe of the eye were unimpaired. The conjunctiva of the affected side was suffused and red. This patient lingered for several weeks after I saw him, complaining greatly of headache and giddiness, and death occurred from the exhausting influence of the hectic irritation caused by the cerebral disease, hastened by an intervening pulmonic complication. At the *post-mortem* a tuberculous mass was found as large as an almond nut, situated at the lateral fossette of the bulb—a depression located above the lateral fasciculus of the bulb at the posterior border of the pons Varolii. At this point the emergence of the apparent origin of the portio dura and portio mollis takes place. The morbid deposit involved the commencing trunks of these nerves, and encroached also slightly upon the contiguous tissue, but did not extend deeply enough to injure the decussated motor fibres of the subjacent structure of the pons.

The intricacies of perverted or annulled sensation are equally difficult of elucidation with those appertaining to motion. The sensory fibres passing from the medulla spinalis decussate at the bulb, slightly above the crossing of the motor fibres, on their passage forward toward the pons and crura cerebri. There may thus happen with the medullary fibres destined for sensation similar varieties in relation to anæsthesia as take place in lesions confined to the motor fibres. Thus a lesion limited to the sensory track in the left side of the pons will be followed by anæsthesia upon the right side. If, however, the lesion of the cerebral substance be also extensive enough to implicate the sensory trunk of the fifth pair as it passes along in the substance of the pons, there will be manifested, in addition to the indirect or crossed anæsthesia, a greater or less loss of sensation of the same side of the face and head as that on which the sanguineous clot or ischæmic softening has occurred. This was exemplified in the following case, which I attended in consultation:

Case.—A—— T——, thirty-five years of age, married, a gentleman of leisure and a free-liver, had several convulsive attacks, attended by loss of consciousness, sensation, and motion, from which he gradually but only partially recovered. From the first attack he experienced loss of power on the right side, and partial loss of sensation of the left side of the face and head. He experienced also pharyngeal trouble in swallowing, and the voice was impaired. He complained of great giddiness, and in consequence was obliged to maintain the recumbent posture. There was also loss of coördinating power during attempts at locomotion, and diminished temperature on the side of the head affected by anæsthesia. This patient improved, under small doses of quinine, phosphorus, and nux vomica, to the extent of being able to walk with tolerable steadiness across his room. The season being warm, it was thought advisable to send the patient to the sea-shore, and by careful journeying he was removed to Long Branch. For two days after the removal very little change took place in his condition, but on the third day a severe convulsive attack came on, attended for the time with complete unconsciousness. The severity of the attack slightly abated, but it left him exhausted, and in a much worse condition than when he left the city. At about three o'clock on the following morning another attack supervened, more severe than either of the former, from which he did not in the least rally, but sank apoplectic in about four hours from the beginning of the attack. Upon *post-mortem* examination, the brain, which was large, appeared externally healthy, except toward the base. There was a general ischæmic condition of the secondary vessels coming from the circle of Willis, more particularly toward the left side. The left middle artery of the brain, lying in the fissure of Sylvius, was partially obstructed with sanguineous clot, as were also some of the arteries supplying the cerebellum and upper part of the medulla oblongata. At the place of emergence of the sensory branch of the fifth pair from the pons on the left side, and surrounding the trunk of the nerve at this part, the cerebral substance to the size of a quarter of a dollar, and extending into the substance of the pons to the depth of some millimetres, was found softened and changed in color. Portions of the cortical surface on the cerebellum also presented evidences of ischæmic change of structure.

The decussations, intercrossings, and commissural connections of one part of the encephalon with another, while they tend to produce the solidarity of complex functional manifestations, constitute the chief difficulty in differentiating the isolated functions of the individual parts of which the cerebral mass is composed. From observations derived from physiological experiments, from anatomical research, and from pathological facts gained from clinical studies and microscopical examinations, it is generally accepted as established that in the majority of cases where paralysis results from lesion or disease of the cerebral hemispheres, the consequent loss of voluntary motion is manifested on the side opposite to that where the lesion has occurred. The records of the older writers, from the time of Aretæus until Mistichelli published his views relating to the decussation at the pyramids, show that observation had anticipated what the Italian anatomist by dissection proved to exist.

A lesion located at a given point along the extent of the motor and sensitive tracks of the cerebro-spinal axis varies in effect according to the relation of the injury to the decussation of the medullary fibres at the anterior pyramids. From injury to the pyramidal fibres above the decussation at the medulla oblongata, along the motor track throughout the *isthmus* of the cerebrum, paralysis on the side opposite to the site of the lesion will result; while below the decussation of the pyramids, along the *medulla spinalis*, with the exception of the possible influence of certain fibres which, emanating from the "columns of Turck," may be prolonged across the white spinal commissure, producing decussating effects in the cervical region, the resulting motor paralysis would be on the same side of the body as the injury.

Sensitive impressions passing from the periphery to the nervous centres undergo the effects of intercrossing similar to the motor impulses, and in lesion upon one lateral half of the cerebrum a loss of sensibility takes place on the side opposite, with the exceptions heretofore noticed, and where the origins of the cerebral sensory nerves that do not decussate are involved. In lesion or injury, however, of one lateral half of the spinal marrow, below the decussation of the pyramids, on account of fibres of sensation crossing the median line at successive points along the extent of the posterior columns of

the spinal cord, there will be loss of sensibility on the opposite side to the lesion, while the motor function will be lost on the injured side. Science is mainly indebted to the researches and experiments of the celebrated French physiologist, Dr. Brown-Séquard, for the interpretation of this action of the *medulla spinalis*, which, although modified or controverted by Vulpian and other authorities, is generally accepted.

Admitting the statement, which dissections have seemed to prove as correct, that the sensitive fibres of the posterior columns of the cord decussate completely *at the bulb*, it may seem contradictory to say that, as there is decussation also along the posterior columns and none on the anterior below the pyramids, sensation and motion travel along the different cords *pari passu* in the same direction, and that lesion on one side of the brain above the pyramids is followed by loss of both motion and of sensation on the opposite side of the body; but it is evident that, taking into consideration the greater amount of functional action to be responded to by the sensory posterior spinal columns on account of the preponderating extent of peripheral surface over the cerebral surfaces dominating the efferent mandates of motion, the posterior columns of the medulla spinalis are charged with a greater number of functions than the anterior columns, and that consequently the existence of a greater complexity of structure should be expected. Thus the posterior columns supply additional nervous power as a distinct centre for reflex action, for the coördination of muscular power, for the organs under the influence of the sympathetic nerves, such as the heart, lungs, stomach, blood-vessels, capillaries, etc., as well as for the functions of carrying on general sensation and automatic motion. The intercrossings and decussations now known to exist along the spinal cord between the posterior columns may serve also as the means of carrying on the functions of reflex action and the other functions just alluded to, while there remains a track of the gray matter to which is allotted the work of transmitting directly sensation from the periphery toward the brain as far as the pyramids, entirely free from the control of the decussations below.

In addition to the preceding details, and viewing the general cerebro-spinal axis as containing a series of individual nervous centres, there may be

present, besides complete hemiplegia or complete hemianæsthesia, a partial paralysis or partial anæsthesia, or both may be combined at given localities, occurring as sequents to external or internal lesion, and presenting symptoms or manifestations explicable physiologically according to the site of the particular lesion.

Brown-Séquard has recently denied the correctness of the doctrine relating to the pathologic cross-action of the encephalic hemispheres, and claims to have established as a fact that motor paralysis occurs most commonly on the same side as that on which the cerebral disease exists, founding his statement upon the examination of some hundreds of cases heretofore recorded by writers during the last two centuries.* The cases, however, brought forward by that eminent *savant* and experimentalist are too deficient in exactitude and minuteness of description to establish a satisfactory basis for the opinion which opposes the principle of cerebral cross-action at present almost universally accepted, and corroborated by numerous unexceptionable observations.

It may be stated, then, as a general rule, that when hemiplegia occurs from cerebral lesion it takes place on the side opposite to that where the lesion exists, and that this doctrine must answer as the guide in practice where trepannation or some other surgical procedure may be required for relief or cure in certain cerebral affections necessitating operative interference as a remedial measure. Instances not in accordance with the general rule may be accounted for by anatomical reasons, such as imperfect decussation of the medullary strands, a change of direction of the nervous fibres, to aberration in conformation, or arrest of development of the cerebral structure. The possibility that anomalous conditions may exist renders it necessary to take them into consideration when operations for secondary chronic affections resulting from traumatic lesion, or for pathological conditions primarily of intercranial origin, are required. From the comparatively small number of cases, however, that may be cited as deviations from the normal condition of structure, the practice of selecting the *place of election* for surgical operations, when indicated in the

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* Vide *Gazette des Hopitaux*, January, 1876.

treatment of internal and occult cerebral affections, upon the side opposite to that of the disease, may be generally relied upon as correct. In relation to cases of direct hemiplegic paralysis occurring on the same side as that of the encephalic lesion, Gall gave as an explanation, which he claimed to be based upon his researches, that the fibres of the pyramids were those alone that decussated. "Suivant nos recherches anatomiques, les faisceaux des pyramides sont les seuls qui s'entre-croisent: conséquemment les lésions des parties du cerveau qui sont une continuation des pyramides, doivent seules communiquer leurs effets au côté opposé du corps. Les faisceaux des lobes postérieurs et d'une grande partie des convolutions médianes du cerveau ne s'entre-croisent pas; par conséquent les effets des dérangements de ces parties ne peuvent pas s'entre-croiser dans le corps." More recent investigations into this subject have demonstrated that the decussation of the medullary fibres is not limited to the pyramidal eminences alone, and that consequently the explanation given by Gall cannot be accepted as correct, as it is founded upon an anatomical error.

By leaving out of present consideration the several bonds of union that reciprocally maintain the communication of the hemispheres by intercrossing, such as the great commissure or corpus callosum, the anterior and posterior commissures, the commissura mollis, and the chiasma of the optic nerves, the study of the decussations and continuity of the longitudinal medullary fibres passing from the spinal cord through the stem or *isthmus of the encephalon* to form the *internal capsule* and the *corona radiata* will be rendered less intricate. Since Mistichelli made his discovery of the *decussation of the pyramids*, Gall, Longet, Huguenin, Vulpian, Meynert, and other anatomists have endeavored to unravel the complications at the bulb; but the more recent observations on the structures that connect the medulla spinalis to the encephalon, as described in a paper read to the French Academy of Sciences by MM. Sappey and Duval (1876), may be considered as the most reliable and complete.

The four columns of white medullary substance composing the upper part of the spinal cord—the anterior, the lateral, the posterior, and the column of Goll—change their direction opposite the *bulb*. Two of the columns decus-

sate in the bulb, one completely, the other only in part; the remaining two do not decussate at all. The *anterior columns*, which partially interlace along the medulla spinalis to form the anterior commissure, do not decussate at the bulb, but they change their direction to ascend upward and outward, so that from being anterior they become posterior. After separating, they pass in their course over the external surface of the lateral and posterior columns, and reunite again behind the posterior columns. Ascending, the fibres become subjacent to the gray substance of the floor of the fourth ventricle, and pass onward, keeping parallel, but not decussating. Reaching the pons Varolii, they traverse its substance, crossing at right angles the superficial layer of transverse fibres, and diverging slightly, they advance to form in part one of the planes of the cerebral peduncle.

The *cords of Goll*, the *fasciculi graciles*, or inner fasciculi of the posterior column of the medulla spinalis, do not decussate, but simply change direction. Opposite the beak of the calamus scriptorius they separate and pass outward along the internal border of the restiform body to penetrate into the cerebellum, and thus in part enter into the formation of the inferior cerebellar peduncle.

The *lateral columns* decussate incompletely; the decussating fibres incline inward and upward toward the mesial line, and cross completely from one side to the other to form what is called the *decussation of the pyramids*, and the superficial part of the anterior pyramids. The fibres that do not decussate continue their course upward on the lateral surface of the bulb, between the *lateral furrow* and the olivary body, to form the *lateral fasciculus* of the bulb. Along the medulla spinalis the lateral columns do not intercross. Immediately above the place where the interlacing of the anterior spinal commissure ceases, the lateral columns, thus far separated by the anterior columns, advance inward, forward, and upward, passing within the branches of the anterior columns, which after their divergence have become external. Advancing toward the mesial line, the decussating fibres of each lateral column become decomposed into numerous fasciculi that intercross with similar fibres to produce the pyramid of the opposite side. The decussating portion of the pyramids extends upward from the neck of the bulb

about ten or eleven millimetres. Above this, the fibres of the lateral column that have contributed to the composition of the anterior pyramids ascend parallel through the pons Varolii, and, with some additional fibres coming from the gray substance of the pons, enter into the formation of the inferior or motor plane of the peduncle of the cerebrum. The anterior three-fourths only of the anterior pyramids are made up from the lateral columns, the deep or posterior fourth being formed by the prolongation of the fibres from the posterior or sensory column of the medulla spinalis.

The *posterior columns* decussate completely,* assuming at a slightly higher point the same direction as the decussating portion of the lateral columns. The fibres pass forward, and, as just stated, form the posterior part of the anterior pyramids. Arriving at a short distance above the neck of the bulb, the decussating fibres of the posterior column follow the oblique direction of the lateral columns, and advance, like them, forward and upward. The two posterior columns, while still parallel, pass through the oval space formed by the branches of the anterior columns as they pass backward to reunite at

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* Anatomists who claim that the posterior columns decussate completely at the bulb disassociate the columns of Goll and the restiforme bodies from those parts of the medulla oblongata described as decussating and passing onward through the pons Varolii to enter into the formation of the crura cerebri, the internal capsule, and the corona radiata. "Ils donnent [les cordons postérieurs] naissance aux cordons de Goll non entre-croisés. Arrivés au niveau du collet du bulbe, ils suivent la direction oblique des cordons latéraux et se portent comme ces derniers en avant et en haut sans les abandonner. Dans ce trajet, les deux cordons postérieurs, constamment adossés, passent dans la boutonnière formée par l'écartement des cordons antérieurs et par conséquent en dedans des corps restiformes et de la portion non entre-croisée du faisceau latéral. Les deux cordons postérieurs restent parallèles jusqu' au dessus de la décussation des pyramides. Mais à ce niveau, ils s'entre-croisent complètement sur la ligne médiane, et forment la portion profonde, postérieure, ou sensitive des pyramides antérieures. Les deux portions, motrice et sensitive, de la pyramide continuent leur trajet ascendant dans la protubérance, où elles sont séparées par une couche de substance grise qui prolonge en bas le *locus niger* des pédoncules cérébraux.....Les cordons de Goll ne s'entre-croisent pas plus que la petite portion du *faisceau latéral* du bulbe. Ils se terminent sur le bord interne du corps restiforme. Les fibres venues du cervelet forment le pédoncule cérébelleux inférieur. Celui-ci se continue en arrière du bulbe sous le nom de corps restiforme, puis ses fibres se dissocient pour donner naissance au système des fibres dites fibres arciformes. Celles-ci faisant suite à celles du corps restiforme, passent, les unes dans l'épaisseur du bulbe en se portant vers la ligne médiane, les autres à la surface du bulbe pour pénétrer dans cet organe par le sillon de la face antérieure à gagner aussi la ligne médiane où toutes les fibres arciformes s'entre-croisent pour former le raphé du bulbe, sorte de cloison antéro-postérieure et médiane. Les fibres arciformes représentent donc des sortes de liens transversaux reliant les cordons de fibres verticales du bulbe."—*Vide* note on pages 202, 203, on the decussation of the sensory conductors of the cord. Also: *Comptes Rendus des Séances de l'Académie des Sciences. Névrologie. Trajet des Cordons nerveux qui relient le Cerveau à la Moelle épinière. Note de MM. Sappey et Duval.* Paris, 1876.

the posterior aspect of the bulb. The motor and sensitive portions of the anterior pyramids continue their progress through the substance of the *pons Varolii*, in which they again become separated by a layer of gray matter, a prolongation of the *locus niger* extending backward from the cerebral peduncle. There is thus met with in the *isthmus* of the cerebrum a system of longitudinal fibres prolonged from the medulla spinalis, decussating at the bulb, and passing onward through the pons Varolii to form in great part the crura cerebri, the *internal capsule*, the root of the *corona radiata*, the *corona radiata* itself, which, fan-shaped, spreads out in different directions to reach the gray substance of the cerebral convolutions.

There is also another set of decussating medullary fibres that connect the cerebellum and the medulla oblongata with the cerebrum. The fibres of the *corpus restiforme* on each side uniting the bulb with the spinal cord diverge from the medulla oblongata, form the inferior peduncle of the cerebellum, and turn outward and backward toward the *corpus rhomboideum* of the cerebellum. From this point a band of medullary fibres emerges to form the superior peduncle of the cerebellum, and reaching the tubercula quadrigemina, passes under these bodies, decussates with the fibres of the opposite side, and terminates in the optic thalami among a nucleus of cells, the *noyau rouge* of Stilling.

It will be seen from this anatomical *aperçu* that, in addition to the transverse bonds of union that are found connecting the encephalic hemispheres with each other, numerous longitudinal decussating fibres are met with along the cerebro-spinal axis—the intercrossings among the posterior columns of the medulla spinalis, the decussation at the pyramids of the motor and sensitive strands, and the decussation below the tubercula quadrigemina of the superior cerebellar peduncles. The sets of fibres enumerated operate by transferring the manifestations or symptoms of injuries or of disease to the side opposite to that on which the pathological change has taken place.

According to the nomenclature introduced by Burdach, the *internal capsule* is described as two large white tracks, which, emerging from the *pons Varolii*, are directed forward, and diverge toward the cortical portion of the

hemispheres. They pass between the two principal basal masses of gray substance, one of which is internal and superior, the other inferior and external. These two white tracks, one on either side, are formed chiefly of the prolongation of the cerebral peduncles, which, at first irregularly quadrilateral, when penetrating into the hemispheres become somewhat flattened from above downward, spread out from behind forward, and when they have passed through the strait of the ganglionic region, spread out by radiating in every direction—in front, toward the frontal hemispheric extremity; in the centre, toward the parietal regions; behind, toward the occipital extremity. Burdach designates the flattened interganglionic portion of the peduncles by the name of *internal capsule.* The radiating portion has been described by Reil as the *corona radiata* (couronne rayonnante of Charcot); the base or root of the *corona* is the point of emergence of the peduncles above the basal cerebral ganglions. The portion of the cerebral peduncles designated as the *internal capsule* being thus particularized, on its inner side, toward the mesial line, are situated the *optic thalamus* and the caudated portion of the corpus striatum. On the outer side of the capsule the lenticular nucleus of the corpus striatum, with its three segments, is met with, and still more outward are successively seen the *external capsule;* the "partition," or *avant-mur;* a small unnamed band of white fibres; and lastly, the gray external surface of the *island of Reil.*

The *internal capsule* becomes a landmark of much importance in studying the effects of injuries, or of abnormal growths, or changes of structure. Anatomical details in relation to disease are not to be viewed as unnecessary, although apparently digressive. Surgical pathology and medical or internal pathology are equally beholden to physiological anatomy for the elucidation of occult abnormal phenomena which could not from other sources be explained. "Est-ce qu'une bonne carte stratégique est jamais trop complète? C'est ainsi que, précisant l'endroit occupé par un foyer hémorragique—la capsule externe ou interne, les noyaux de la substance grise, le pied de la couronne rayonnante, etc.—vous parviendrez à constater, s'il y a lieu, des différences symptomatiques en rapport avec des différences relatives au pronostic. Un exemple, emprunté à l'histoire de l'hémorragie cérébrale, vous

prouvera sur le champ que ce n'est point là un travail superflu. Si un foyer hémorragique n'a intéressé que la capsule externe, le malade guérira, suivant toute vraisemblance, malgré l'étendue de la lésion et sans infirmité; s'il occupe, au contraire, la capsule interne, dans le cas où le malade survit, il persiste toujours une paralysie avec contracture indélébile."* It must, however, be borne in mind that pressure resulting from disease or growths located external to the *internal capsule* may for a time produce symptoms of lesion of the *internal capsule*, the effect of the pressure being transmitted to the fibres of the *internal capsule*. Symptoms thus produced complicate the diagnosis. With a knowledge of the brief anatomico-physiological points just given, it can be understood without difficulty how some cerebral injuries associated by extensive external evidences of severity are sometimes attended by symptoms of shock and collapse comparatively trivial, while other lesions of ostensibly lesser marks of violence are followed by overwhelming and fatal results.

For example: In May, 1881, I was called in consultation by Dr. Freeman, of West Farms, to see a gentleman who, from domestic troubles, had made an attempt to commit suicide by shooting himself with a pistol. He committed the act about a quarter of a mile from his house, the ball entering the right temple an inch behind the external angular process of the frontal bone, on a line running from that point toward the upper part of the helix, and about three-quarters of an inch below the temporal ridge. He was knocked down by the concussion and the shock, but immediately got up, and began to walk homeward. Upon reaching his house he threw himself upon the sofa, and coolly told his wife that he had shot himself. When seen by me two hours afterward, his pulse was beating about seventy to the minute, regular, and moderately full. The surface was cool, but no cold sweat. There was no sickness of the stomach, and general and special sensibility showed no impairment. He answered questions intelligibly, and made but little complaint of pain or other discomfort. The wound, which was not large, presented the usual appearance of gunshot wounds at the point of entrance—ragged,

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* Charcot, *Leçons sur les Localisations dans les Maladies du Cerveau.* Paris, 1876.

contused, and inverted edges, with the contiguous surface discolored by the powder from the proximity of the pistol when fired. There was very little bleeding, and a small portion of cerebral matter oozed out of the orifice. Reaction to a moderate extent took place some hours after. Later on, symptoms of cerebral inflammation were ushered in, and in two days the patient died in an attack of epileptiform convulsion. At the *post-mortem* examination the bullet was found embedded in the white substance of the frontal lobe, among the fibres of the corona radiata, above the line and somewhat in front of the anterior border of the corpus callosum.

In contradistinction to this case, another came under my notice at the battle of Spottsylvania, May 18, 1864. A soldier of Burnside's corps was brought into the surgical head-quarters from the battle-field wounded in the right temple by a bullet, which pierced the cranium about two inches from the external angular process, at a point a short distance from the anterior and upper portion of the helix of the ear. He was perfectly insensible, breathing stertorously, cold surface, with rapid and feeble pulse—in fact, all the symptoms of profound collapse. This patient lingered but a few hours before death ensued. Owing to the surroundings and bustle of the moment, a *post-mortem* examination was not held, but from the severity of the collapse there is no doubt that in this case the ball penetrated the more vital parts of the brain, wounding, besides important blood-vessels, the fibres of the internal capsule and the basilar ganglia.

A typical illustration of the relative influence of the locality of an injury upon the general system, and of the temporary immunity at least from severe shock and collapse in injury occurring at the anterior cerebral lobes, is met with in the case reported by Drs. Harlow and Bigelow, of a young man who was engaged tamping a blasting charge in a rock with a pointed iron rod, "three feet seven inches in length, one inch and a quarter in diameter, and weighing several pounds." The charge accidentally exploded, causing the iron rod to be propelled through the air with the pointed end foremost. It struck his face in front of the anterior angle of the left ramus of the lower jaw, and passed entirely through the top of the head in the frontal region, near the sagittal suture, and was picked up at some distance, covered

with "blood and brains." The missile entered, as previously stated, immediately in front of and external to the anterior or inner angle of the inferior maxillary bone, proceeded obliquely upward, and, as described by Dr. Harlow, passed under "the junction of the superior maxillary and malar bones, comminuting the posterior wall of the antrum, entered the base of the skull at a point the centre of which is an inch and a quarter to the left of the median line, in the junction of the lesser wing of the sphenoid with the orbitar process of the frontal bone, leaving an opening in the base of the cranium, after the natural effects at repair by the deposit of new bone, of one inch in its lateral, by two inches in its antero-posterior, diameters."*

The patient, a young man (P. P. Gage, aged twenty-five), as related, was for a moment stunned, but within an hour after the accident he was able to walk up a long flight of stairs and give the surgeon an intelligible account of the injury he had sustained. His life was for a long time despaired of, but he finally recovered, and lived twelve and a half years afterward. He died ultimately of an epileptic convulsion, at a distance from medical supervision, and no *post-mortem* of the brain was made. Through the exertions of Dr. Harlow, however, the skull was exhumed, and is now preserved in the Medical Museum, at Boston. Dr. Bigelow, of that city, examined this man while living, two years after the accident, and thus describes the appearances then presented: "A linear cicatrix of an inch in length occupies the left ramus of the jaw near its angle.....The eyelid of this side is shut, and the patient unable to open it; the eye considerably more prominent than the other.....Upon the head, and covered by hair, is a large unequal depression and elevation.....A piece of the cranium of about the size of the palm of the hand, its posterior border lying near the coronal suture, its anterior edge low on the forehead, was raised upon the latter as a hinge to allow the egress of the bar; still remains raised and prominent." The farther track of the bar through the frontal bone is not described, but it is evident that the lesion is situated anterior to the coronal suture, and that the whole track is included

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* *American Journal of Medical Science*, July, 1850: "Recovery from the Passage of an Iron Bar through the Head," read before the Massachusetts Medical Society June 3, 1868. Boston, 1869.

within the region of the brain known as the *præ-frontal* region, and that, therefore, "the absence of paralysis in this case is quite in harmony with the results of experimental physiology. The only other region which the bar could have injured is the tip of the temporo-sphenoidal lobe and the outer root of the olfactory bulb."*

This case has been quoted as one in which the patient suffered no damage, physically or mentally; but although the shock and collapse proved comparatively slight, and he escaped the effects of encephalitis, generally fatal after such extensive lesions, the *ideation* was affected to a degree which plainly indicated injury to the gray matter of the frontal convolutions, changed the whole tenor of his after-life, and modified a character possessing acknowledged meritorious traits to one approaching imbecility. In regard to his mental condition after his recovery, Dr. Harlow states "that his contractors, who regarded him as the most efficient and capable foreman in their employ previous to his injury, considered the change in his mind so marked that they could not give him his place again. The equilibrium, or balance, so to speak, between his intellectual faculties and animal propensities seems to have been destroyed. He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operation, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, though untrained in the schools, he possessed a well-balanced mind, and was looked upon by those who knew him as a shrewd, smart business man, very energetic, and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly that his friends and acquaintances said he was 'no longer Gage.'"

In computing the primary influence of traumatic lesions upon the nerv-

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* Vide *Localization of Cerebral Disease.* By David Ferrier, M.D., F.R.S. London, 1879.

ous system in the production of shock and collapse, the concurrent effects resulting from extensive wounds of the large arteries, veins, etc., must also be considered as aggravating and intensifying the symptoms, which presently appear as the combined result that is radiated upon the general organism. For example: Last July I was requested to see a young man, about twenty-five years of age, and apparently of good constitution, who had just shot himself with a revolver pistol. The ball had entered the cranium at the *occipital protuberance*, slightly to the right of the median line, splintering the inner table of the skull, and traversing the *torcular Herophili* at the point of junction of the right lateral sinus. It then diverged about an inch, and entered the right occipital lobe at its inferior and posterior aspect, passing through its substance in an oblique direction. It then entered the cuneiform lobule, which it traversed also in an oblique direction from below upward and from without inward. Still continuing its course, it passed through the quadrilateral lobule from below upward and from without inward toward the superior extremity of the *fissure of Rolando.* Traversing this fissure, the ball entered the paracentral lobule, and still passing upward, was found partly emerging through the cortical substance, half a centimetre from the upper margin of the great median fissure, in contact with the inner table of the calvarium, thus taking a course from below upward and from without inward in nearly a straight line after entering the cerebral substance.

On my visit to this patient I found him lying on the floor of the bath-room, his head resting in a shallow paper-box cover, which had been so placed by those who first saw him immediately after the shooting. The blood was running in a stream from the wound, a pool of which had collected inside the cover. The carpet for some distance around was completely saturated. The bleeding had been continuous since the receipt of the injury, and from three to four pints of blood must have been lost. I immediately enlarged the narrow opening of the scalp, and exposed the bony orifice through which the blood was streaming. A Nelaton probe was gently introduced into the opening, but was soon arrested by striking against a hard substance, which proved to be a portion of bone splintered from the

internal table of the skull. The hemorrhage was stopped by tamponing the bony aperture, through which the blood was still profusely flowing. During this time the patient was entirely insensible, pulse frequent and feeble, surface pale, temperature below the normal point, breathing labored and gasping (about fourteen respirations to the minute), pupils largely dilated and immovable. This man was senseless from the first, for he was seen by one of the inmates of the house, a few moments after the report of the pistol was heard, lying unconscious on the floor. Wounds of the occipital region such as that in this case are not necessarily speedily fatal from the shock and collapse, but more frequently terminate from the effects of the subsequent encephalitis. The profuse hemorrhage, however, in addition to the nervous impression of the original injury (the gunshot wound), produced a complex effect—in other words, a prolonged or secondary shock and collapse —which soon resulted in extinction of vitality. It is from complications such as occurred in this case, added to the shock primarily produced on the system, that traumatic lesions received on the battle-field prove often as speedily fatal as in those instances where life is destroyed by the influence of the *wind-ball*, or by the intensity of the shock and collapse resulting from the lesions produced on the organism by such agencies as the scattering fragments of explosive shells.

In the general concussion and commotion that take place in the encephalon from shock, either from direct injuries or from such as are transmitted through the medium of the nervous cords and medulla spinalis, the brain is often so disturbed that along with the accompanying shock and collapse there is present a partial or total loss of sensibility, with a corresponding paralysis of voluntary motion. Under such conditions, if the patient survive, the principal locality and extent of an injury may become declared as the general symptoms of shock and collapse disappear, the persistent impairment of function of some special organ or of several organs remaining in those localities where the intensity of the injury has been greatest or been mainly concentrated. The following case is an example of this: On the 12th of last January, about two o'clock in the morning, I was called to see C—— H——, fifty-five years of age, a gentleman of good constitution and of temperate

habits, who had just received a severe injury. He had been to a public ball, and was about starting for home in company with his son. After leaving the cloak-room, and in passing down the stairs, he accidentally tripped, and fell head-foremost for the distance of several steps. In the endeavor to recover himself he glided sideways, and struck the wall heavily with the left side of the head, opposite the temporal region. He was picked up unconscious, and was brought to his house in a carriage in that condition. He had received other injuries about the arms and chest, breaking some ribs, but the principal symptoms present were those proceeding from cerebral disturbance. I saw him about an hour after the accident. He continued insensible, had lost the power of voluntary motion, and was breathing irregularly, and sometimes stertorously; there was some jactitation, small and frequent pulse, cold surface, and the other general signs of concussion with collapse following severe shock. 13th (evening).—Some reaction, but little improvement. 15th.—Symptoms of concussion subsiding; restless; feverish; pulse 100; temperature nearly natural; cough troublesome; sensibility returning; answers questions irrelevantly and by monosyllables. 20th.—Respiration better, 22 to the minute; cough better and easier; intelligence improving, but unable to explain himself or express his wishes by words, although he knows what he wants; laboring under amnesic aphasia; pupils responsive; takes light nourishing food; treatment has been moderately antiphlogistic. From this time forward he continued to improve generally, with the exception of comparatively unimportant complications, gaining in appetite and the capability of taking exercise, walking frequently out-of-doors in company with an attendant, but still remaining incapable of expressing his wishes or ideas, of the exact purport of which he appeared to be perfectly cognizant. Although known to him for several years, upon my entering his room he could not call my name, though he distinctly recognized who I was, and upon my name being spoken he would repeat it, which in a short time he would again fail to recall; and while amusing himself at a game of cards, he would be unable to speak the character of the card, although aware when the suitable time came for it to be played. During the following months of February, March, and April he continued to improve in his general physical

condition, and, in fact, might be considered in good health; but the aphasia, or the defect of the mental capacity necessary for conveying information by articulate speech, remained, with only slight amelioration.

According to the pathological researches of Bouillaud, Brocca, Charcot, and others, the nervous centre for articulate speech is seated upon one side of the brain, and, as a rule, at the third convolution of the left frontal lobe. It must therefore be inferred in the case under consideration that although the entire encephalon suffered primarily from the general perturbation that followed the cerebral concussion, the intensity of the injury fell upon the left hemisphere, and in a greater degree upon the third convolution of the frontal lobe of the corresponding side than upon the other cerebral regions.

Permanent lesions of certain parts of the encephalon may thus result from perverted nutrition and change of structure, in a manner similar in progress to those secondary morbid phenomena that take place in the spinal system as sequences to severe injury and shock.

In investigating the influence of the medulla oblongata upon the numerous functions over which it presides, it is obvious that a knowledge of the physiological anatomy of this part of the nervous system and of its various relations will afford an explanation of many of the important effects, immediate and remote, of shock and collapse that take place when its structure and intimate connections have been impressed by severe direct or indirect concussion or lesion. The cineritious nuclei of gray matter and the numerous motor and sensory cranial and spinal nerves that at their origin are connected with the bulb account for the relative number of centres of reflex action which are located there, and which become morbidly affected from pathological causes. The convulsive contractions and contortions of the face and eyes that are at times observed after severe injuries are the result of abnormal impressions made on the *bulb*, and thence radiated among the correlative muscles along the facial and ocular nerves. In a similar manner other muscles are brought into morbid excito-motor action. The fourth pair of nerves govern the contractions of the superior oblique muscles of the eye in producing the spasmodic rolling of the eyeball; the sixth pair convey the morbid impression to the external oblique muscle, turning the eye outward by its spasmodic

contraction; the seventh pair accomplish the convulsive contortions of the facial muscles; the fifth pair, the setting and opening of the jaws by their *motor* portion. The glosso-pharyngeal nerve influences the action of the pharyngeal muscles, impeding or annulling the power of deglutition. The pneumo-gastric nerve modifies the character of the respiration from the stertorous breathing of coma to the rapid and irregular gasping efforts of cerebral concussion; and the slow or quick action of the heart and the sickness of stomach in shock are owing to the disturbed function of the same nerve. The hypoglossal disturbs the motor action of the lingual muscles, and modifies or paralyzes the articulation and speech; and the *spinal accessory* convulses the muscles which it supplies. The expression of the pupils of the eyes becomes modified by their contraction or dilatation through the medium of the reflex influence resulting from the connection of the fibres of the *internal oblique branch* of the *third pair* with the lenticular ganglia of the sympathetic.* The secretory function even is modified at the bulb; and by means of the vertical afferent and efferent fibres which traverse the bulb to form continuous connection with the medulla spinalis, the entire system of voluntary muscles may be thrown into convulsive commotion by morbid impressions of a severe character transmitted through the action of the medulla oblongata. The medulla oblongata thus becomes the principal focus and causative source of most of the systemic effects that are the result of severe shock followed by collapse.

Several parts which enter into the composition of the bulb are endowed with characteristic excitability and conductability. The excitation of the anterior or inferior two-thirds of the *anterior pyramids* is followed by conductive movement, while the stimulation of the upper or posterior third, formed by the continuous fibres of the posterior column of the spinal cord, is attended by marked signs of acute sensibility. The effect of stimulation of the lateral portions of the bulb, including the *lateral fasciculus*, or of the *olivary bodies*, is not definitely known at present. The *restiform bodies* have

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* According to Stilling, the fibres of the *motores oculorum* pierce the cerebral peduncle and locus niger, and arise from a gray nucleus in the floor of the aqueduct of Sylvius, close to the bulb.

usually been described as extremely sensitive, and as being direct prolongations of the posterior column of the medulla spinalis. According to recent investigations, the posterior columns of the cord, as just stated, penetrate into the bulb to form the deep or sensitive layer of the pyramids, and the restiform bodies are mainly made up of fibres from the cerebellum which are continuous with the *arciform* fibres of the bulb. The *restiform bodies*, however, like the posterior portion of the anterior pyramids, are sensitive and excito-motor.

Above the neck of the bulb the effect of excitation, whether artificial, from disease, or from injury, is crossed; for above this point the principal fasciculi of the bulb decussate—those proceeding from the lateral columns of the medulla spinalis crossing on a level with the *neck*, the fibres from the posterior columns slightly above those coming from the lateral columns. *Below the neck* of the bulb the fibres of the *anterior columns* of the medulla spinalis interlace along the median line to form the anterior commissure, but do not decussate completely, while the *lateral columns* do not interlace or decussate. The *posterior columns* possess fibres that decussate entirely from one side to the other across the median line. It follows from this that in unilateral lesion or disease of the medulla spinalis *below* the neck the seat of the resulting paralysis of motion will be localized on the same side as that on which the abnormal excitation or change of structure occurs, while from the same source *anæsthesia* on the opposite side is met with.

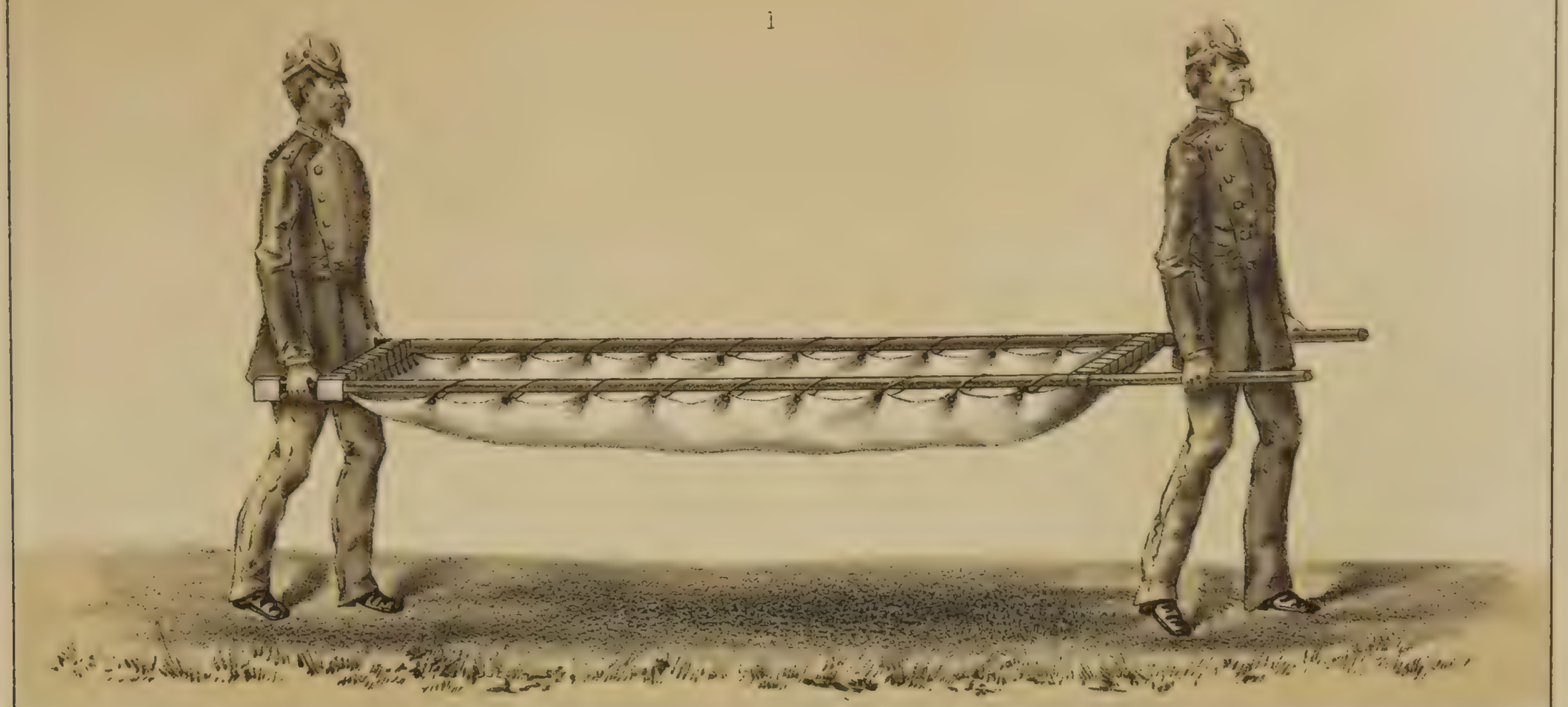
Besides the decussating and non-decussating vertical fibres, the bulb is supplied with a certain number of horizontal fibres that do not decussate, most of which are connected to the nerves originating from the bulb, so that a lesion of those fibres produces a paralysis of the corresponding nerve. At times, however, the lesion extends deeper, and is located not alone on those non-decussating fibres, but attacks also a portion of the fibres of the bulb itself. When a lesion or change of structure occurs at the base of the bulb, at its junction with the inferior part of the *pons Varolii*, toward the place of emergence of the seventh pair of nerves, a double or alternate paralysis will be produced, that is, a paralysis upon the side of the body opposite to that of the seat of the injury or disease, and a paralysis of the facial nerve,

or motor nerve of the face, upon the same side as that where the lesion or the abnormal change of structure is situated.

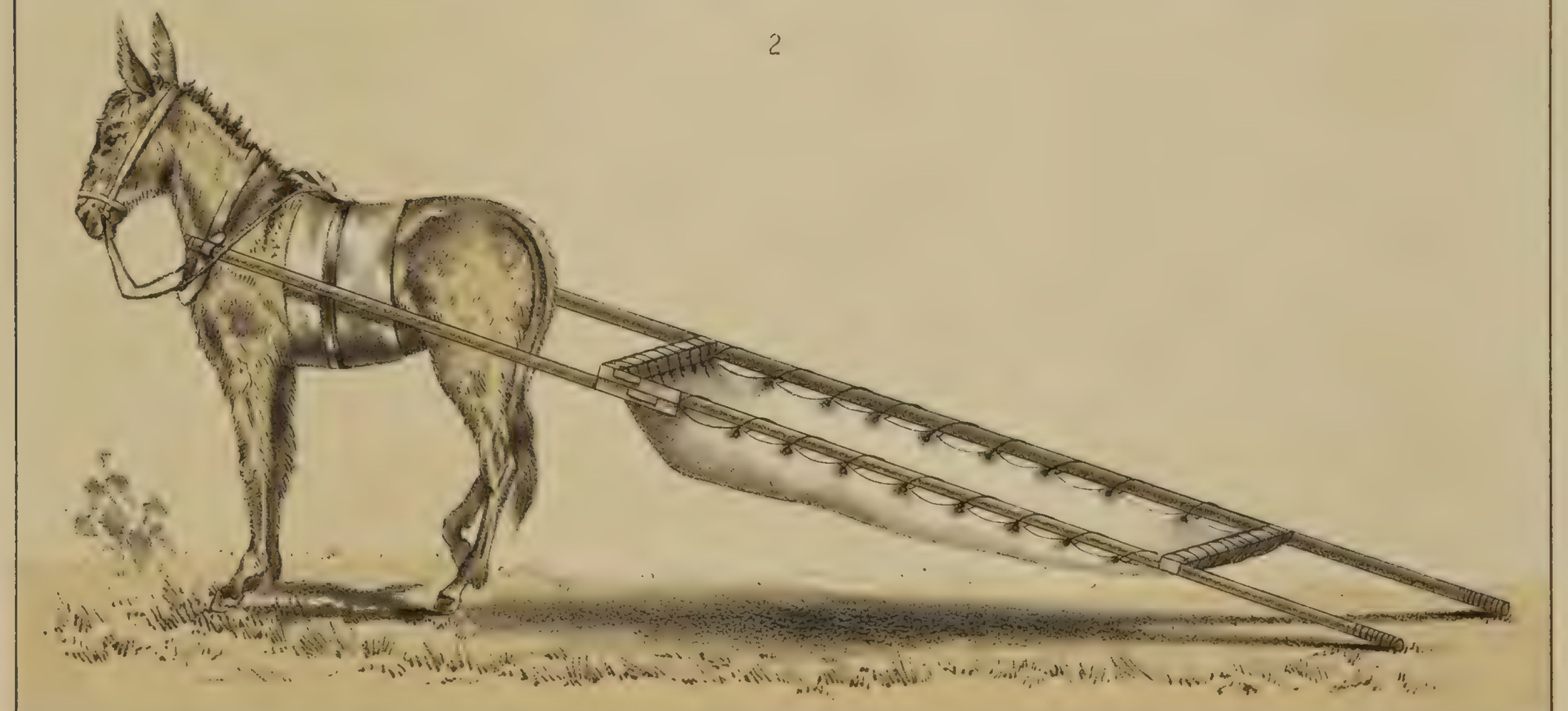
In localizing injuries of the cerebrum, it should not be overlooked that the two nerves of each pair are not altogether independent of each other in their action. At the roots or the real origin of the nerves of a pair possessed of similar function, fibres of communication exist, passing from one side to the other—true commissural fibres that maintain a synchronism of action between the two nerves. In this way the simultaneous movements of the eyelids in closing and opening, as in the act of winking, can be explained. The double distortion of the features and of the eyes in unilateral injuries of the encephalic hemispheres or in apoplectic seizure shows the synchronous action of the *portio dura* and of the *motores oculorum*.

A basis for forming an opinion in relation to the localization of injuries, and to the gravity and duration of shock and collapse, may be gained also by observing the abnormal manifestations of the reflex actions which follow upon lesions implicating the encephalon, and referring them to the aberration of certain functions which are at fault. As has previously been stated, the bulb, considered as an organ of excito-motor action, plays an important part in the symptomatology of shock and collapse, on account of the numerous functions that become perturbed when it is the seat of serious commotion or of structural injury. The centre of vitality, the *nœud vital*, is located at the inferior part of the fourth ventricle, near the beak of the calamus scriptorius. It corresponds to the nucleus of cells, or real origin of the pneumogastric, constituting the mixed trunk of the sensitive nerves of the bronchi and of the principal motor nerves of respiration. As respiration is carried on through the intervention of the excito-motor influence of the pneumogastric, and transmitted from the lungs to the bulb, a marked deviation from or disturbance of the normal action of the respiratory apparatus will indicate that the medulla oblongata must, directly or indirectly, be the seat of pathological impressions of greater or less intensity. In like manner the bulb, as an excito-motor centre, through the intervention of the pneumogastric and cardiac nerves, modifies the regulating nervous influence of the heart, controls the movements and rhythm of this organ

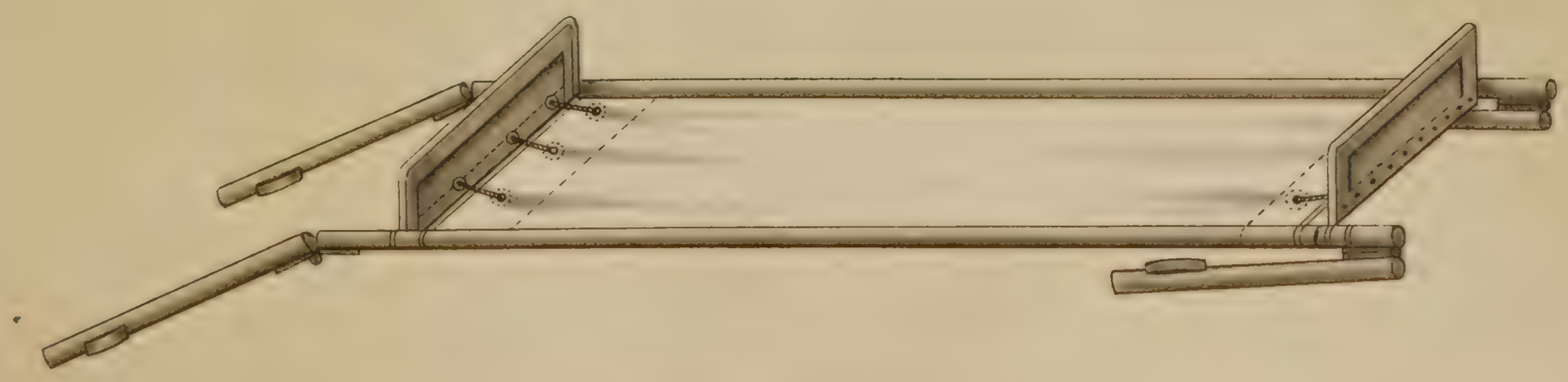
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Julius Bien & Co. lith

PRIMARY TREATMENT OF INJURIES

TRANSPORT OF WOUNDED

№ 1 Combined Hand and Horse Litter, used as a Hand Litter. № 2 The same, used as a Horse Litter_ Dr. Greenleaf
№ 3 United States Army Two-Horse Litter

and its condition of contraction or of relaxation, and induces the abatement or arrest of its action while in *diastole* or in *systole*. Symptoms of serious perturbation of the central organ of the circulation, whether characterized by the slow action resulting from *compression*, or the rapid and feeble pulsation of *concussion*, or by the tardy, weak, and irregular beat of approaching dissolution, will signify that the structure of the bulb is suffering from the effects of some transmitted abnormal stimulation, or is laboring under the morbid impression of direct injury. The effects of the stimulation made at the isthmus of the pharynx by the contact of alimentary material are carried to the bulb by the sensitive filaments of the glosso-pharyngeal and pneumogastric nerves. The impression arriving at the bulb, the motor filaments that emerge from the *lateral furrow* complete the excito-motor circle, and produce the propelling movements of the muscles of the pharynx. In severe shock difficulty of swallowing is often met with, indicating the abnormal influence exerted upon the nervous centre located at the bulb that presides over the function of deglutition. The experiments of M. Claude Bernard show that the reflex centres of certain secretions are seated at the bulb. According to this physiologist, the irritation produced by puncture of the fourth ventricle influences the secretion of the kidneys in relation to the quantity and the composition of the fluid secreted. Irritation made near the beak of the *calamus scriptorius*, between the origin of the pneumogastric nerve and that of the acoustic, determines the appearance of saccharine matter in the urine, and a temporary diabetes is the result. If, however, the point of irritation be changed, and made somewhat lower than the point mentioned, a simple polyuria will take place, but no secretion of sugar. If, again, the puncture be made more elevated than at either point, albuminuria will be produced. The secretory action of the kidney, as well as of other glandular structures, is often changed as one of the effects of shock and collapse.

In contradistinction to what may frequently happen in the slow progress of internal or medical disease, the several or individual symptoms of shock just enumerated can seldom become manifested in an isolated manner in severe traumatic impressions made upon a structure so complicated as that

of the medulla oblongata, where so many centres of varied excito-motor action are localized and so closely connected; yet the functional analysis of the component parts of which the bulb is made up will have to be considered in order to comprehend the aggregate or combined pathological effects that spread or radiate over the organism in serious perturbations of this complex part of the nervous system.

Pons Varolii, or Annular Protuberance, and Middle Peduncles of the Cerebellum.—After the bulb and its immediate connections, including the inferior cerebellar peduncles, the annular protuberance, the middle peduncle of the cerebellum, the superior peduncle of the cerebellum, and the two cerebral peduncles come in turn to transmit along the *isthmus of the encephalon* to the great ganglionic or basal cineritious masses the various hurtful impressions that culminate in the production of the general phenomena of shock and collapse.

The *Pons Varolii* or *Annular Protuberance* in its structure contains the prolongations of each of the columns of the medulla spinalis. The greatest number of the fibres pass into the cerebral peduncles; some of them are also found in the middle peduncles of the cerebellum. The superior peduncles of the cerebellum are probably made up in part of a continuation of a portion of the fibres of the posterior column of the medulla spinalis, which, after having passed from the bulb with the restiform bodies and traversed the cerebellum, pass forward and inward to terminate among the cineritious cells of the optic thalamus. The annular protuberance rests on the basilar process of the occipital bone, and is placed before and above the medulla oblongata, behind and below the crura cerebri, or cerebral peduncles, and between the peduncles of the cerebellum. It serves as a commissural connection between the lateral lobes of the cerebellum, and in its interior, which is abundantly supplied with cineritious or gray nervous substance, are contained the prolongations forward of the greater part of the fasciculi of the medulla spinalis. It is important to designate the limits of the annular protuberance, although by artificial lines, in order to define its relations and describe its exterior conformation, as well as to insure precision in pathological research. On its anterior or basilar surface the limits of the

protuberance are made sufficiently distinct by the transverse and somewhat semicircular grooves of separation that run between it and the bulb below, and the crura cerebri in front and above. On the sides and on the posterior aspect, however, there are no visible lines of demarcation, and for these boundaries artificial limits have to be assigned. Two lines, one on each side, drawn vertically on the outside of the point of emergence of the fifth pair of nerves, and made to join the horizontal or transverse grooves just mentioned, will with these comprise the quadrilateral space that the anterior or basilar aspect presents. As regards the posterior or upper surface of the pons, its limits will be best understood by drawing two other artificial lines, directed transversely, one of which, continuing behind the antero-superior border of the protuberance, would fall behind the tubercula quadrigemina, while the other line, serving as the continuation of the postero-inferior groove, and directed toward the posterior aspect of the pons, would pass about two or three millimetres below the lateral angles of the *fourth ventricle*. If different sections be now made in the direction of the preceding fictitious lines, it will be observed that the annular protuberance is cuboid in shape, and that the tubercula quadrigemina are not, as stated by some writers, situated on the pons, but on the upper surface of the crura cerebri.

The protuberance, thus isolated from its correlative cerebral connections, will present six surfaces, of which the anterior and posterior are the most important.

The *Anterior Surface* is somewhat convex, and on it a number of well-marked white transverse fibres are observed, of which it is mainly composed. Toward the anterior margin and inside of the lateral boundary line the motor and sensory fibres of the fifth pair emerge. At the centre the deep median groove is seen, in which is lodged the basilar artery, coursing along to branch into the two posterior cerebral arteries. On each side of the median groove two elevations are met with that are thrown into relief by the passage onward, to reach the crura cerebri, of the anterior pyramids under the more superficial transverse fibres.

The Posterior Surface.—After removing the cerebellum, incising longitudinally the valve of Vieussens, and keeping apart the superior cerebellar

peduncles, the posterior surface is seen comprised between the fictitious lines already designated. It constitutes the anterior wall of the fourth ventricle, and is formed in part by the upper and posterior portion of the bulb, but mainly by the posterior portion of the protuberance. It consists of a layer of cineritious or gray substance, streaked by oblique white fibres, some of which go to form the origin of the acoustic nerve. A groove runs along the middle of this surface that leads above into the aqueduct of Sylvius, or *iter a tertio ad quartum ventriculum*, and below is continuous with the posterior median fissure of the bulb and medulla spinalis. On either side of this groove two longitudinal elevations are seen, prolongations through the pons of the *lateral fasciculi* of the bulb. External to these elevations the two superior cerebellar peduncles present themselves, which, with the addition of fibres from the restiform bodies, circumscribe laterally and above the fourth ventricle. These peduncles, before passing under the tubercula quadrigemina, are crossed by some of the oblique fibres of the *ruban* of Reil, coming from the *intermediary fasciculi* of the cord. Outside of the cerebellar peduncles a furrow taking an antero-posterior direction exists, the lateral furrow of the isthmus (*sillon latéral de l'isthme de l'encéphale* of Cruveilhier), on either side of which a small portion of the posterior surface of the protuberance is seen continued from the corresponding middle peduncle of the cerebellum.

The Lateral Surface.—The four additional surfaces, so called, are conventional, and result from different sections made in the direction of the artificial lines and grooves just enumerated in designating the limits of the protuberance. On each side the protuberance is confounded with the middle cerebellar peduncles, and is isolated from them by the vertical section made external to the emerging point of the fifth pair of nerves. The lateral section thus made exposes posteriorly the cut surface of the corresponding middle cerebellar peduncle; more forward, a convex surface, from which emerge the fibres of the fifth pair of nerves, seen also on the *anterior aspect.* Above this the *anterior superior groove* is met with; then the triangular fasciculus of the isthmus and the external face of the superior cerebellar peduncle.

Antero-Superior Surface.—A vertical section made parallel to the upper anterior border of the protuberance brings into view the superior aspect of the protuberance, and exposes the commencement of the *crurà cerebri*, and the white medullary fibres and dark cineritious matter—the *locus niger* of Soemmering—which enter into the composition of the *crura cerebri.*

Postero-Inferior Surface.—Another vertical section, carried across the upper border of the bulb in the direction of the *antero-inferior groove* that separates the bulb from the *protuberance*, exposes its lower surface, and brings into view the cineritious substance and medullary fibres that pass from the medulla spinalis and medulla oblongata to enter into the composition of the protuberance.

The Peduncles of the Cerebellum and the Peduncles of the Cerebrum. —The annular protuberance serves as a centre from which radiate the most important parts that enter into the formation of the encephalic mass, and that maintain anatomically the intercommunication among its individual organs. Posteriorly the medulla oblongata, and anteriorly the two crura cerebri, seem to pass from it as offshoots; laterally the two middle cerebellar peduncles branch to the cerebellum, while the inferior and superior cerebellar peduncles form connections with it, although not properly belonging to its structure.

On each side the protuberance presents its cerebellar peduncles of attachment, the inferior, the middle, and the superior, the middle being the largest of the three.

The Middle Peduncles of the Cerebellum.—The middle peduncles of the cerebellum, made up entirely of white material, are two large cords that take their origin from the sides of the protuberance, and pass outward to become merged among the plates of the cerebellum. They are somewhat flattened from above downward, and are convex externally. Superiorly they are covered by the superior and lateral lobules of the cerebellum, and inferiorly are surrounded by the acoustic portion of the seventh pair of nerves and the nervous lamellæ that constitute the lobules of the pneumogastric nerve. They are continuous directly on each side with the transverse fibres of the protuberance, and a portion of the *intermediate* or *lateral fasciculi* of the bulb

also enter into their formation. They serve as a commissural communication between the two hemispheres of the cerebellum, and establish also a connection between the cerebellum and the antero-lateral column of the medulla spinalis.

The Superior Peduncles of the Cerebellum, the Valve of Vieussens, and the Ribbon of Reil (ruban of Reil).—The superior peduncles of the cerebellum are seen on the upper plane of the *isthmus of the encephalon.* They enter into the formation of the fourth ventricle, and serve as a medium of communication between the cerebellum and the cerebrum, and between the cerebrum and the posterior columns of the medulla spinalis. Emerging from the anterior part of the cerebellum, above the middle cerebellar peduncles, they pass from behind forward and from without inward, converging toward the tubercula quadrigemina. The fibres of each pass under those bodies, decussating there, and cross over from one side of the median line to the other, to terminate among the red cells of the optic thalami. The valve of Vieussens unites them along the anterior part of their inner border; above, they are covered by the lamellæ of the anterior part of the cerebellum, and crossed laterally by fibres from the *ruban* of Reil—the lateral triangular fasciculus of the isthmus. By their external border the superior cerebellar peduncles are in relation with the posterior surface of the annular protuberance, to which they adhere, and from which, and from the middle cerebral peduncles outwardly, they are separated by the antero-posterior furrow already indicated. Toward the summit of the valve of Vieussens the fourth pair of nerves, or *nervi pathetici*, are seen to emerge.

The Valve of Vieussens is a membraniform connecting layer of medullary substance, passing anteriorly between the inner borders of the superior cerebellar peduncles, and separating the cavity of the fourth ventricle from the anterior and superior lamellæ of the cerebellum. It is triangular in form; the base is lost in the median cerebellar lobe between the two vermiform lobules; the summit is placed behind the *testes* of the tubercula quadrigemina, at the point of convergence of the two superior peduncles of the cerebellum.

The Triangular Lateral Fasciculus of the Isthmus (Faisceau triangulaire

latéral de l'Isthme of Cruveilhier)—*Ruban of Reil.*—Passing forward as a continuation of part of the intermediary fasciculus of the bulb, a bundle of white fibres, forming the lateral triangular fasciculus of the isthmus, is seen upon each side of the annular protuberance, placed external and inferior to the superior cerebellar peduncle. It here presents three margins, each about a centimetre in length, a superficial surface which is free, and an under surface which is adherent to the contiguous structures. The inferior border is separated from the middle cerebellar peduncle and the lateral part of the protuberance by a marked furrow, the *lateral furrow of the isthmus.* The anterior border is in juxtaposition to the *testes* or posterior border of the tubercula quadrigemina; and the posterior border is in relation with the anterior part of the superior cerebellar peduncle, some of its fibres crossing over to become merged among the fibres of the valve of Vieussens, while the greater part pass forward toward the mesial line, decussate under the tubercula quadrigemina, and, like the superior peduncles of the cerebellum, terminate among the cineritious cells of the optic thalami. The fibres of the *ruban* of Reil thus form a decussating bond of communication between the medulla oblongata and the optic thalami.

The Inferior Peduncles of the Cerebellum.—By elevating and holding apart the cerebellum from the bulb, the posterior column of the medulla spinalis, ascending along the medulla oblongata, is seen passing upward to bifurcate, one portion passing inward to form the posterior sensitive part of the anterior pyramids, the other portion passing outward and backward to form the restiform bodies and the inferior peduncles of the cerebellum.* These peduncles become merged in the substance of the cerebellum, and as the superior peduncles of the cerebellum emanate from the anterior contiguous part of the cerebellum and pass to the optic thalami, a communication

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* Some modern anatomists describe the inferior peduncles of the cerebellum as emanating from the substance of the cerebellum, and, under the appellation of restiform bodies, as passing into the posterior column of the medulla oblongata, where they also send off some of the *arciform fibres* of the bulb. In order, however, to render the description of the parts more easily followed, it is better to consider the passage of the posterior columns of the medulla oblongata and medulla spinalis as given in the text. *Vide* MM. Duval and Sappey, *Comptes Rendus de l'Institut.* Paris, 1878.

is thus maintained between the medulla spinalis, the medulla oblongata, the cerebellum, and the cerebrum.

The Peduncles of the Cerebrum—Crura Cerebri.—The *cerebral peduncles* extend from the anterior and lateral part of the annular protuberance to the ganglionic masses situated on the inferior wall of the lateral ventricles—the tubercula quadrigemina, the optic thalami, and the corpora striata. They are seen on the base of the brain as two large bundles of longitudinal white fibres that diverge, taking a direction forward, upward, and outward, placing in communication the cerebrum with the other parts of the nervous system. The postero-inferior extremity of each peduncle is rounded, and continuous with the vertical or longitudinal fibres of the protuberance. As each crus advances it becomes somewhat flattened from before backward; and in front the fibres spread out, and become decomposed into a series of fasciculi, some of which are lost in the corpora striata, some among the cells of the optic thalami, and others in the tubercula quadrigemina, the greater part entering into the composition of the *internal capsule*, and, passing onward in different directions toward the cerebral convolutions, form the fan-like expansion of the *corona radiata*.

The peduncles have each four aspects having important relations. Viewing the base of the brain turned upward, and elevating the convolution of the hippocampus so as to open the canal of Bichat, the entire *inferior face* of the cylindrical portion of the cerebral peduncle is seen. It is limited posteriorly by the anterior border of the protuberance, and in front by the commissure of the optic nerves and the *tractus opticus*, by which last-named band and the posterior cerebral artery it is also surrounded.

The Superior Face.—The upper aspect of the peduncle is surmounted posteriorly by the tubercula quadrigemina, anteriorly and outwardly, when about to form the *internal capsule*, by the *optic thalami*. By scraping off a portion of those bodies the fibres of the upper part of the cerebral peduncle are made visible.

The External Face, surrounded by the convolution of the hippocampus, enters into the anterior boundary of the *fissure* of Bichat. The upper border is marked by the *antero-posterior furrow*, above which is seen the *ruban* of

Reil and the tubercula quadrigemina. The posterior cerebral artery ascends around this surface, and the *nervi pathetici* or fourth pair cross it from behind forward in passing from its origin through the *fissure* of Bichat.

The Internal Face.—The internal aspect of the cerebral peduncle is nearly plane, and from it the filaments of the *motores oculorum* or third pair of nerves are seen to emerge. It is separated from that of the opposite side by an interpeduncular layer, the *espace perforé interne*, through the foramina of which numerous vessels pass, and which concurs to form the inferior wall of the third ventricle. Viewing the parts from before backward in the lozenge-shaped space between the cerebral peduncles, and bounded in front by the posterior border of the optic nerves and their commissure, the pituitary stem, the *tuber cinereum*, the pisiform tubercles, and the interpeduncular cribriform plate are seen, acting probably as connecting nervous media and centres among the contiguous parts of the cerebrum.

The Fissure of Bichat.—In juxtaposition and in close relation with the external and lateral portions of the cerebral peduncles and the tubercula quadrigemina, the linear interval leading from without inward into the lateral ventricles of the brain, known as the canal or fissure of Bichat, may be noticed. This opening is bounded anteriorly and laterally by the parts of the *isthmus cerebri* just mentioned, while the posterior and lateral border is made up on each side by the convolution of the hippocampus which forms below part of the *cornu Ammonis*, the *corps bordé*, and the *corps godronné*. These structures, formed of cineritious matter and longitudinal fibres, may serve as communicating bands to modify and convey impressions to certain parts of the brain.

The Internal Structure and Functions of the Annular Protuberance, and of the Cerebellar and Cerebral Peduncles.—It is through pathological research, and by the analysis of the uses and abnormal action of the medulla spinalis and the medulla oblongata, that clinical exactitude in reference to injuries upon them is attained. Equally it is from a knowledge of the intimate structure and special functions of the annular protuberance and of the cerebellar and cerebral peduncles that the locality or seat of pathological changes and morbid manifestations may be learned when these structures

become affected by disease, or by irritations, direct or reflected, resulting from such injuries as are followed by shock and collapse.

The substance of the annular protuberance is composed of transverse fibres coming from the cerebellum, and of vertical or longitudinal fibres extending from the bulb to the *crura cerebri*, among which a considerable mass of gray cineritious matter is disseminated. A succession of superimposed planes of transverse and of vertical fibres enters into the formation of the pons in the following order, from before backward: 1, transverse superficial fibres; 2, motor vertical fibres prolonged from the anterior pyramid; 3, transverse fibres; 4, vertical sensitive fibres from the posterior part of the anterior pyramid; 5, transverse fibres; 6, vertical fibres prolonged from the anterior column of the medulla spinalis; 7, vertical fibres, somewhat oblique, situated between this layer and the gray substance of the fourth ventricle.

The *transverse fibres* are continuous externally with the two middle peduncles of the cerebellum, so as to form a broad commissure that places in communication the two hemispheres of the cerebellum. Some of these fibres extend directly from one peduncle to that of the opposite side; others are lost in the gray substance of the protuberance, and, after interlacing along the median line, enter into the formation of the median *raphé*.

The vertical or longitudinal fibres extend from the bulb to the *crura cerebri*, and form three distinct fasciculi that are crossed by the transverse fibres. 1. A vertical anterior fasciculus unites the superficial motor portion of the anterior pyramid of the bulb to the inferior plane of the peduncle of the cerebrum. This fasciculus is a prolongation from the lateral column of the medulla spinalis. 2. A middle vertical fasciculus, somewhat smaller, extends from the posterior part of the anterior pyramid of the bulb to the external part of the superior plane of the cerebral peduncle. This middle fasciculus is oblique upward and outward, while the first-named fasciculus is entirely vertical, running parallel to that of the other side. The middle fasciculus is separated from it by a thin layer of transverse fibres, and also by a collection of gray substance, the inferior prolongation of the *locus niger*, which terminates tapering toward the bulb. This fasciculus is sensitive, and

is continued from the posterior column of the medulla spinalis. 3. A posterior vertical fasciculus, placed in close proximity to the floor of the fourth ventricle and crossed by transverse fibres, is prolonged from the anterior column of the medulla spinalis, which becomes posterior on a level with the bulb.

The gray matter of the protuberance is in relation with the gray matter of the bulb and medulla spinalis below, and with that of the crura cerebri, the *locus niger*, above.

As already stated, the *middle peduncles* of the cerebellum are composed entirely of white medullary fibres passing transversely from one hemisphere of the cerebellum to the other. Toward the median line some of the fibres are confounded with the substance of the *protuberance*, while the greater portion—those toward their external extremity—radiate outward, and are sunk among the laminæ of the cerebellum.

The internal structure of the *inferior cerebellar peduncles* is composed of white fibres continuous below with the white fibres of the posterior column of the medulla spinalis, and above with the white substance of the cerebellar hemispheres toward the cineritious substance of the *corpus rhomboideum.*

The internal structure of the *superior cerebellar peduncles* is also composed of white fibres, extending forward and inward from the anterior part of the cerebellum, above the middle cerebellar peduncles, to pass under the tubercula quadrigemina, and, intercrossing there with the fibres of the opposite side, terminate finally among a group of nervous cells in the substance of the optic thalami.

The internal formation of the *crura cerebri* is composed of white fibres proceeding from the medulla spinalis directly, and indirectly of fibres passing forward and inward from the cerebellum (the continuation of the superior cerebellar peduncle), and of cineritious matter (the *locus niger* of Soemmering). The group of fibres from the medulla oblongata, their passage through the crura, their relation to the *locus niger*, and the part they take in the constitution of the internal capsule, have previously been considered. The internal structure of the crura cerebri is laid out in layers, or planes, presenting an inferior, a middle, and a superior plane. The inferior plane, or

that in view on the base of the brain (*crusta*, *pes*), is made up of fibres continuous with the motor fibres of the medulla spinalis that traverse the bulb and the annular protuberance. Anteriorly they ascend below the optic thalami, and, passing between the caudate and lenticular ganglia of the *corpora striata*, contribute mainly to the formation of the *internal capsule*.

A fasciculus of sensitive fibres is described by Meynert as being continuous below with the posterior or sensitive portion of the corresponding anterior pyramid. Above, this fasciculus has been described as entering into the formation of the posterior part of the *internal capsule*—the lenticulo-optic region—and curving backward to be lost in the cortical layer of the occipital lobe of the cerebrum.

The white fibres forming the superior plane of each *crus* situated above the locus niger are composed of two fasciculi—an internal, formed of the superior cerebellar peduncle; an external, constituted by sensitive fibres that are continuous, below, with the posterior or sensitive portion of the corresponding anterior pyramid, and, above, passing onward to terminate among a group of cells situated before and above the red nucleus—*noyau rouge*—of Stilling.

In brief, the internal structure of the crura cerebri is composed of fibres extending from the spinal cord and the bulb to the cerebrum, and also of fibres springing from the gray substance of the bulb and of the annular protuberance. The longitudinal or vertical fibres that pass from the medulla spinalis to the basal ganglia (*optic thalami* and *corpora striata*) traverse the annular protuberance and the crura cerebri, the motor fibres following the inferior plane of the crura, the sensitive fibres the superior plane.

The principal mass of gray cineritious matter (the *locus niger*) that enters into the composition of the crura cerebri and forms the partition between the inferior and superior planes of the crura is continuous below with the cineritious matter of the annular protuberance, and in front ceases toward the middle part of each *crus*.

In addition to the *locus niger*, three other smaller collections of gray substance are met with: 1, a small mass at the internal part of the superior plane near the middle line; 2, a small collection of cells situated outward

and downward in the substance of the superior plane; 3, a small mass placed below the aqueduct of Sylvius, from which spring the third and fourth pair of cranial nerves. These collections of cineritious matter, in conjunction with that of the *locus niger*, when seriously perturbated, as in shock from cerebral injury, serve in part to produce the morbid manifestations following such accidents, and, on the other hand, when the vitality is not extinguished, to act as recuperative centres in restoring the *vis nervosa* necessary in establishing reaction.

Some organs are complicated in their relations, and their histological structure is imperfectly understood, so that the precise localization of obscure affections occurring in them is usually attended with difficulty. Where the cerebro-spinal system is mainly implicated this is especially the case, and here it is principally by means of physiological knowledge that obscure pathological conditions resulting from disease or injury can be unveiled and ascertained. Where numerous organs possessed of varied functions are placed in close juxtaposition, as in the *isthmus of the encephalon*, and where the structure of one organ is confounded or continuous with that of another, it might seem impossible to indicate the exact seat of an injury affecting one or more of them. Each part receiving a distinctive conventional name has its different function, and consequently there must follow a corresponding aberration of function and pathological manifestation when subjected to irritative causes. In injuries of the encephalon, isolated or collective symptoms of gravity remaining persistent after the subsidence of the immediate effects of *concussion* may serve to designate the locality of the principal seat of lesion, and for the conclusion of a favorable or unfavorable prognosis. Such symptoms occurring in the collapse, and prolonged for many hours without signs of amelioration, would indicate that the *crura cerebri* and motor strands of the *internal capsule*, or some other parts of the *isthmus of the encephalon*, were seriously at fault, and that the prognosis, or influence of the locality of the lesion, would be decidedly unfavorable.

Physiological Relations of the Annular Protuberance and of the Cerebellar and Cerebral Peduncles to Shock and Collapse.—From the

sketch just given of the composition of the annular protuberance, and of the cerebral and cerebellar peduncles, and their numerous connections, it is evident that severe commotions or lesions of this part of the nervous system will be attended by symptoms of serious collapse. In injuries of the brain, the locality or seat of intensity of the lesion may be inferred from the extent of aberration of function which is manifested by the part injured.

From the presence of the gray matter among the white fibres, the annular protuberance is to be regarded as the seat of several nervous centres. The presence of the motor and sensitive fibres of the fifth pair of nerves, which traverse its structure, and the contiguity of the gray nucleus common to the real origin of the portio dura or seventh pair and the patheticus or sixth pair, on a level with the line of separation between the annular protuberance and the bulb, and also the relation of the protuberance to the strands of the medulla spinalis, impart to it the character of a centre of reflex action, as well as of voluntary motion and of sensibility. Vivisections made upon animals, where the *superior* aspect of the annular protuberance has been artificially irritated, prove, from the manifestations of pain exhibited, that the upper surface of the protuberance is endowed with sensibility. According to Longet, excitation of the *inferior* or *anterior* surface by the action of the réophores of a galvanic apparatus, carried a little deeply into the substance of the protuberance, will produce epileptic convulsions. It may therefore be inferred that in severe shock involving this part of the cerebrum, convulsion and loss of sensibility may supervene.

The protuberance is the nervous centre which originates, through the intervention of the medulla spinalis, the movements necessary for locomotion. It is also the centre which controls by coördination the contraction of the muscles required to maintain station or fixed posture. Dr. Cottman, now of this city, related to me an illustration of this which came under his observation while travelling by steamboat on the Mississippi. An explosion of the boiler took place while the steamer was stopping at a landing, which proved destructive to many of the passengers. One of these, an adult male of middle age and of strong build, was thrown some distance into the air. He landed upon his feet, but looked around in a dazed manner, darted across

the gang-plank to the shore, and rushed along at a rapid pace for a distance of several rods, when he suddenly fell dead. In this instance the shock was of such severity as to devitalize the general system so as to produce almost immediate death. The annular protuberance, however, retained a certain amount of vitality, sufficient to carry on locomotion by reflex action for an appreciable time.

Mrs. B——, aged thirty, met with an accident illustrative of the effect of shock from injury to the brain in which the annular protuberance to a certain degree escaped. While driving in Central Park her horses became frightened, and got beyond the coachman's control. Mrs. B——, in her alarm, opened the carriage door and sprang out while the horses were running at a rapid rate. The animals soon became manageable, however, and were stopped. A lady who was with her, and who had remained quietly in the vehicle during the accident, looked back, and saw Mrs. B—— crouching on the ground in a sitting posture. In the leap from the carriage she had lost her balance, and struck the ground on the side and back of her head. A large mass of braided hair protected the scalp behind, so that there was no mark of contusion. She was taken care of by the Park police, carefully placed in her carriage, still maintaining a sitting posture, though quite unconscious, and slowly driven home, where she was brought into the house and placed on a bed. She could not be induced to speak. I was called in by the family physician about two hours after the accident. She was still unconscious, the eyes open, pupils contracted, pulse small and frequent, respiration rapid, skin slightly below the normal temperature, and very restless, tossing from side to side with such force as to render it difficult to keep her in bed. This condition required constant watching and restraint, as she automatically made violent efforts to get up; and even after her speech was restored the jactitation and restlessness continued. Her first expression was "Oh!" constantly repeated, and then "Oh dear!" "Oh dear me!" As she regained the use of her tongue she gradually recognized friends, and talked more or less rationally; but it was about three weeks after the accident, and after she was well enough to be up and dressed and moved into an adjoining room, that, as she expressed it one morning, she "came to herself." She

passed her hand over her eyes, nose, and face, and said: "Now I know myself. What has happened?" It was about three months before she went out, and the first time she became so nervous that they had to take her home, when she soon recruited. Her mind and memory, from being rather dull, improved. But she could recall nothing of the unfortunate drive after entering the Park. Her health since has been very good, without trouble in the head. Her pulse at first was frequent and feeble, so that brandy and water were given at regular intervals. There was no abrasion of the skin except about the knees, and her clothes were not torn—scarcely soiled; yet it was a remarkable case of concussion, without inflammation or apparent lesion, which recovered without ill effects, clearly showing that the function of the annular protuberance may remain even where the rest of the cerebrum is so much injured as to annul for the time being most of its functions.

The experiments made on living animals by Longet, Vulpian, and Flourens prove the influence upon locomotion of the annular protuberance. When a student in Paris I assisted at a series of vivisections conducted by M. Longet, which were directed toward the study of the functions of the nervous system, and particularly of the cerebro-spinal system. Numerous vivisections were made which proved, by ablation of certain parts of the cerebrum, the diversity of function and the independence of action of individual parts of the encephalic mass. Thus, the brain could be removed as far as the medulla oblongata, and yet several important functions, such as the respiratory act, would still be performed; also, the brain could be taken away as far as the annular protuberance, and station and locomotion would remain. These experiments were reported at the time, and have since often been repeated, forming the basis for other researches. If the cerebrum of a fish be removed, leaving the annular protuberance intact, it will swim as if the brain were uninjured. In the same experiment with a frog, by removing the brain, but leaving the protuberance, it will remain immovable in its natural attitude. If irritated, it will take a leap from the influence of reflex action; it will then resume its original attitude. If thrown into water, it will swim until an obstacle is encountered, and upon being placed again in water it will once more commence to swim.

Similar manifestations occur with the pigeon when the cerebrum is removed, with the exception of the annular protuberance. It will still maintain the standing position, and if excited by some mechanical or chemical source of irritation it will make efforts to walk. If it be thrown into the air, it will open its wings and execute the movements of flying until it falls to the ground. On the other hand, if the annular protuberance be destroyed in an animal it will become incapable of standing erect, or of making any movement, either reflex or direct. These experiments go to prove that the brain proper is not of itself the centre necessary to motion, but that by direct excitation or by reflex action, through the influence of the annular protuberance, produced by contact with the ground or from other causes, a person may walk automatically without being conscious of it, the normal voluntary action of the brain or of the will having induced motion in the first instance.

Clinical and pathological observations derived from chronic cerebral affections confirm the results obtained from physiological experiments made upon living animals. A typical case of disease of the protuberance, where the situation of the morbid condition of the parts implicated was exactly ascertained by the autopsy, communicated by the late Professeur Bérard aîné, and referred to by Longet, is translated as follows:

"A laborer, while working, was taken suddenly with a ringing in the ears. Several moments later he was attacked by a pain so severe as to draw cries of agony from him. He commenced to run, as though to escape a danger which threatened him, falling soon, however, and presenting the following symptoms: complete loss of consciousness; immobility without dilatation of the pupils; immovableness of the globe of the eye; mouth half open, and without apparent twitching; some little movement in the tongue, without permanent deviation of the point; respiratory movement frequent and irregular, occasionally stertorous; the wings of the nose contracted convulsively with the muscles of respiration. Twice there was violent sneezing, while the patient, who was lying on his back, bent forward. The limbs were in a state of rigidity that was easily overcome. This contraction, during which the arms were drawn inward and the thumbs bent, was not permanent. The contraction of the muscles of the neck was not strong enough

to prevent the head from obeying the laws of gravity. The only signs of general sensibility were a convulsive movement of the right arm when the skin was pinched, and a similar movement when piercing it with the lancet for the purpose of bleeding. The patient died five hours after the beginning of the attack, and the symptoms were not observed during the last two hours before death. At the *post-mortem* the cerebral protuberance was found changed into a pouch filled with partly coagulated blood, and mingled with nervous substance softened and colored by the liquid."

In severe shock implicating the annular protuberance the prolongation of the anterior strands of the spinal column into the protuberance explains the convulsive agitation that often takes place. The extension of the injury to the mechanism at the bulb, interfering with the function of respiration, accounts for sudden death from apnœa. When both halves of the protuberance are greatly implicated, paralysis of the four members will be present. When the lesion is located on one side only, a hemiplegia may supervene on the opposite side of the body to that of the injury. In three cases cited by Longet where the annular protuberance was affected by sanguineous effusion, at the moment of attack *une sorte de propulsion irrésistible*, or irrepressible automatic rapid movement, as if rushing forward to escape from threatened danger, took place.*

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* Many points in relation to the physiology of the medulla spinalis still remain undecided, more especially in regard to the decussation of the Sensory Conductors of the Cord, and to the posterior columns, and to the posterior third of the lateral columns. It is generally conceded that the motor principle is contained in the anterior columns and in the greater portion of the antero-lateral columns, and that the sensory or *afferent* principle resides in the posterior columns and in the posterior portion of the lateral columns, toward the origin of the posterior roots of the rachidian nerves. The principal point at issue is the seat of the decussation of the nervous mechanism that transmits the impressions of sensation from the part irritated to the encephalon.

In paralysis or hemiplegia occurring from lesion of the brain, paralysis of motion generally occurs upon the side of the body opposite to the cerebral injury, and most frequently paralysis of motion only is present. In cases, however, where both motion and sensation are annulled upon one side of the body, the part of the brain affected is also found to be upon the side opposite to the lesion. There is thus evidence of decussation of the conductors of afferent sensitive impressions, as well as of the efferent conductors of the motor stimulus. The experiments of Fodéra in 1822, and later of Van Deen and of Brown-Séquard, were directed toward proving the decussation of sensory fibres in the Cord itself below the medulla oblongata. Fodéra made a longitudinal section of the spinal cord exactly in the median line, and entire loss of sensation and partial loss of motion was the result below the point of division. As in this experiment it is only possible to divide the fibres passing from one lateral half of the cord to the other, it is supposed that the sensory conductors must decussate in the spinal cord. Van Deen, after

The continuity of the transverse and superficial fibres of the annular protuberance (the pons Varolii) with the structure of the middle peduncle of the cerebellum indicates a similarity of function. If in vivisection one of the middle cerebellar peduncles proper be cut in its course, the animal will roll upon itself—on the longitudinal axis of the body. The same phenomenon takes place, although in a less degree, if the superficial transverse fibres of the protuberance be divided a short distance outside of the middle line. The movement of rotation is much more rapid in proportion as the section is made toward the middle cerebellar peduncle proper. After this section the movements and position of the eyes become remarkable. The eye of the wounded side is carried downward and forward; that of the opposite side is thrown upward and backward, producing an extraordinary and strange expression of the countenance.* The changed character of the

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the section of one lateral half of the spinal cord in the frog on a level with the third lumbar vertebra, observed that there seemed to be no real loss of sensibility in the posterior extremity on the side on which the half of the spinal cord had been cut.

Brown-Séquard repeated the experiment of dividing the spinal cord along the centre, obtaining as a result complete paralysis of sensation upon both sides in all parts below the section. In other experiments (1849–58) published by the same savant it is stated that if one lateral half of the spinal cord is divided, sensibility is abolished in the parts below the section upon the opposite side of the body. After the implantation of the posterior roots of the rachidian nerves upon the medulla spinalis, the course of their fibres shows that the sensitive fibres from the posterior roots pass along the posterior columns to a limited distance, and then leave them to enter the central cineritious matter. It is undoubtedly in this gray substance that the fibres decussate and pass from one side of the cord to the other. The fibres of the nerves in the cord extend but a short distance, some passing upward and others downward before decussating, and in this manner a system of isolated decussations is formed for limited segments of the cord.

Taking for granted that the white fibres of the medulla spinalis are necessary, in conjunction with the gray matter, to complete the mechanism of the transmission of sensation, there is nothing to contradict the theory that as the white fibres from the rachidian nerves send their fibres only for a short distance, ascending and descending into the gray matter, the impression conveyed from the original seat of irritation—at the foot, for example—should be conveyed across the gray commissure only to a portion or small segment of the medulla spinalis, isolated or limited in extent by the distance traversed by the nervous fibrils of each nerve among the gray cells of the medulla forming the gray commissure. As the gray matter is continuous along the whole track of the cord, as well as across the gray or posterior commissure, the original impression reaching the cord, besides being transmitted to the opposite side of the cord, may thus still be propagated along the cord, ascending on the same side as that of the point of irritation up to the decussation of the fibres of the posterior cord at the bulb; and thus the afferent impression of sensation may travel to the brain on the same path as the efferent or motor stimulus, although in the opposite direction. Loss of sensation as well as of motion occurring in certain lesions of the brain on the side opposite to that of the lesion may be accounted for in this manner, while at the same time admitting the decussation of sensation in limited segments of the medulla spinalis *below* the bulb.

* *Vide* Longet, *Anatomie et Physiologie du Système Nerveux*, Tome i., p. 433.

eyeball may be accounted for by the influence of the lesion upon the origin of the sixth and third pair of nerves.

A question arises as to the nervous organ from which the motor impulsions transmitted by the cerebellar peduncles are derived. The middle cerebellar peduncles are continuous directly with the transverse fibres of the annular protuberance. A portion of the intermediate or lateral fasciculus of the bulb enters into the formation of these peduncles; and while they serve as a commissure between the cerebellar hemispheres, they also establish a relation between the cerebellum and the antero-lateral fasciculus of the *medulla spinalis*. The impulsive force (*force nerveuse*) is thus apparently transmitted to the middle cerebellar peduncles directly from the cerebellum, and indirectly from the medulla spinalis.

The *superior cerebellar* peduncles may be considered as prolongations of fasciculi coming from the posterior column of the medulla spinalis. They pass forward from the cerebellum and form part of the superior plane of the cerebral peduncle. They are not endowed with mobility, but are sensitive, and they probably transmit impressions to the encephalic ganglia placed before the cerebellum. When the function of the brain is not entirely annulled, their lesion may be the source of pain and distress.

The *inferior cerebellar peduncles* are in reality the direct continuation of the posterior fasciculi of the medulla spinalis, in other words, the corpora restiforme. They are endowed with sensation, and when affected by disease or severe injury may be the source of sensibility and pain.

The *cerebral peduncles* are mainly composed of the two orders of fasciculi, motor and sensitive, which pass as prolongations from the medulla spinalis. They inclose in their substance the principal strands that enter into the formation of the *internal capsule*, and serve to conduct both the impressions of sensation and the principle of voluntary movement. Experiments upon living animals, according to Longet, show that when a division of a cerebral peduncle is made immediately in front of the annular protuberance, or somewhat in advance, the animals execute or perform a circular movement of the *manége*, which always takes place upon the side opposed to the lesion, as happens in the section of one of the middle cerebellar peduncles;

in other words, that the right cerebral peduncle being injured, the animal performs the evolution of manége from right to left, thus implying a crossed hemiplegia. M. Lafargue offers as the explanation of the rotatory movement on the axis of the body that follows section of the middle cerebellar peduncle, and of the evolution of manége after the lesion of the cerebral peduncle, the crossed hemiplegic effects resulting from the section of the parts mentioned, and not to any distinct motor function. "Il n'est pas étonnant que ce mouvement succéde immédiatement à la section d'un pédoncule: car cette mutilation *tout en produisant l'hémiplégie croisée*, porte une si rude atteinte à l'ensemble de la locomotion, que les membres les plus forts ne peuvent pas soutenir le poids du corps: alors l'animal tombe sur le côté paralysé.....Supposez qu'un lapin paralysé du côté gauche (par la section du pédoncule droit) tombe sur ce côté (gauche): les membres droits, occupant le plan supérieur, pousseront à gauche et en bas, et, dans leurs premiers efforts, ils feront décrire au corps un quart de cercle, de manière à mettre le ventre en l'air; l'impulsion de droite à gauche répétée faisant exécuter de nouveaux mouvements en quart de cercle, les extrémités paralysées, le dos, les membres sains, le ventre, occuperont successivement le plan supérieur, ainsi de suite. Et le mouvement rotatoire résultera de cette succession."

A similar explanation is offered to account for the evolution of manége after section of the cerebral peduncle. "Si vous produisez une hémiplégie (ce qui a lieu *incomplétement* et d'une manière croisée, après la section d'un pédoncule cérébral), les membres les plus vigoureux, ne trouvant pas de puissance antagoniste, pousseront la totalité du corps vers le côté paralysé; et s'ils ne conservent pas assez d'énergie pour opérer un déplacement proprement dit, une translation complète, toutes les impulsions latérales, s'ajoutant les unes aux autres, produiront un mouvement circulaire dont le côté paralysé sera le centre."

The gray matter of which the cerebral peduncles are partly composed indicates that they act the part of a nervous centre; but their function is liable to be confounded with that of the annular protuberance, causing difficulty in arriving at precise conclusions. The peduncles

are sensitive and excito-motor, as is proved by the severe pain evinced by animals when these organs are irritated, and by the convulsive agitation which takes place. Lesions of the cerebral peduncles produce crossed effects, so that a lesion of one of the peduncles gives origin to a hemiplegia upon the opposite side. A lesion of the cerebral peduncle may also give rise to a paralysis of the common motor nerve of the eye, and of the fourth pair or superior oblique, if the fibres of these nerves be involved.

As part of the radicles of the third pair spring directly from the gray substance of the cerebral peduncle, and pass without decussating to the five muscles of the eyeball, a lesion of the peduncle may thus give rise to an alternate paralysis; that is, from disease or injury of the cerebral peduncle of the *right* side a hemiplegia of the *left* side of the body may take place, while a paralysis of the muscles supplied by the third pair of nerves will occur on the *right* side.

Symptoms occurring after injuries to the head denoting a disturbance of the functions of the cerebellar and cerebral peduncles indicate that a lesion has taken place among the deep-seated parts of the *isthmus of the encephalon*, and that the succeeding collapse, if persistent, will be characterized by dangerous severity.

In connection with the functions of the cerebellar and cerebral peduncles, it may be remarked that, according to the experiments of Flourens, symptoms simulating lesion of the cerebral peduncles may occur from injury to the semicircular canals of the internal ear. M. Flourens, in experimenting upon the different semicircular canals in living animals, obtained results presenting much analogy with those observed after lesion of the different cerebellar and cerebral peduncles.

For example, after section of the semicircular canals, according to the canal operated on, the animal will roll upon itself, rotating on the long axis of the body, or will precipitate itself forward with force, or will struggle as if to make a series of somersaults backward. These locomotor eccentricities are attributed to the intimate connection between the nervous fibrils distributed over the ampulæ of the semicircular canals and the real origin of the

nervous radicles of the portio mollis emanating from the crus cerebri and the fibres of the cerebellar peduncles.*

Whatever explanation may be given of these peculiarities in relation to the effects of section of the semicircular canals, there is no reason for doubt regarding the character and details of the effects produced. These experimental facts should not be overlooked in considering the influence of the seat or locality of injuries followed by shock and collapse.

The intercrossing effects of the cerebral peduncles take place by the decussation of the general mass of nervous fibres of which they are composed. Those of the inferior plane (motor fibres) and those of the superior external plane (sensitive fibres) decussate in the substance of the rachidian bulb; those from the superior cerebellar peduncle intercross in the substance of the cerebral peduncles themselves as they pass below the tubercula quadrigemina.

Tubercula Quadrigemina.—The influence upon vision attributed to the *tubercula quadrigemina* calls attention to these organs when, after severe

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* "Si l'on coupe le *pont de Varole*, c'est-à-dire le faisceau de fibres transverses, l'animal roule sur lui-même, selon l'axe de sa longueur. La section des fibres ou *pédoncules transverses* détermine donc la rotation de l'animal sur lui-même. C'est précisément, ou fort à peu près du moins, ce que fait la section du canal semi-circulaire horizontal.

"Si l'on coupe les pédoncules cérébraux, aux quels s'unissent les fibres ou *pédoncules antérieurs* du cervelet, l'animal se précipite en avant avec force. La section des fibres ou pédoncules antérieurs détermine donc une suite de mouvements en avant; et c'est aussi ce que fait la section du canal vertical supérieur ou antérieur.

"Si l'on coupe enfin les fibres ou *pédoncules postérieurs* du cervelet, l'animal recule; il fait ou tend à faire une suite de culbutes en arrière. La section des fibres ou pédoncules postérieurs du cervelet détermine donc une suite de mouvements en arrière; et c'est encore ce que fait la section du canal vertical inférieur ou postérieur.

"A quoi tient donc cette force singulière des canaux semi-circulaires? Elle tient aux rapports des nerfs de ces canaux avec les fibres de l'encéphale.....

"Si l'on suit dans l'encéphale le nerf des canaux semi-circulaires, on le voit bientôt arriver à l'encéphale et là se diviser en trois faisceaux nerveux. L'un de ces faisceaux va aux fibres transverses du cervelet ou *pont de Varole;* l'autre aux fibres droites de l'encéphale, c'est-à-dire aux pédoncules cérébraux; l'autre aux fibres postérieures du cervelet ou *corps restiformes.*

"Voilà donc trouvée la cause des singuliers effets des canaux semi-circulaires: d'une part, la section de chaque canal produit un mouvement dont la direction est toujours la même que celle du canal coupé; d'autre part, la direction des mouvements produits par la section des fibres du cervelet et de l'encéphale est toujours la même que celle des fibres coupées; enfin les filets nerveux du nerf des canaux semi-circulaires ont leur origine dans ces fibres de l'encéphale, lesquelles sont, tour à tour, transverses ou droites, antérieures ou postérieures, et dont les effets sont opposés comme les directions. C'est donc de ces fibres opposées, c'est donc de ces fibres intimes et profondes de l'encéphale que le nerf des canaux semi-circulaires naît et tire le principe de sa force et de son action."—Flourens, *Recherches expérimentales sur les Propriétés et les Fonctions du Systéme nerveux.* Paris.

injuries of the head or other parts of the organism, followed by shock and collapse, their function becomes persistently impaired.

The tubercula quadrigemina are placed in front of the cerebellum and the valve of Vieussens, and between the posterior portions of the optic thalami. They are situated behind the middle ventricle, above the aqueduct of Sylvius, and over the point of decussation of the superior cerebellar peduncles. The pineal gland is also in relation with them. While the base of the choroid plexus, the venæ Galeni, and the posterior border of the corpus callosum constitute the middle portion of the external margin of the fissure of Bichat, the corpora quadrigemina form the middle part of the internal border of the same fissure. The optic nerves or second pair take their real origin in the tubercula quadrigemina. They are the seat of the visual perceptions, and of the reflex movements that produce the contraction and dilatation of the pupil. The existence of nervous fibres can be traced putting in communication the gray substance of the tubercula quadrigemina with the nuclei of real origin of the third, fourth, and sixth pair—the motor nerves of the eye.

The tubercula quadrigemina are constructed mainly of gray matter covered by a thin layer of white substance. They are connected to the *corpora geniculata* of the optic thalami by two fasciculi of fibres, one of which places in communication the two anterior tubercles (*nates*) with the corpus geniculatum externum, while the other passes from the posterior tubercles (*testes*) to the corpus geniculatum internum. It is the gray or cineritious substance that gives prominence to the four tubercles of which they are composed. An attentive examination reveals delicate transverse and longitudinal fibres traversing the gray substance, the former coming from the *ruban of Reil*, the latter from the *superior cerebellar peduncles*. The white fibres, some of which are commissural, serve to maintain the relations of the tubercula quadrigemina with the rest of the cerebro-spinal axis.

Experiments by vivisection, and more particularly pathological observations, attest the intimate connection of the tubercula quadrigemina with the rest of the nervous apparatus of vision.

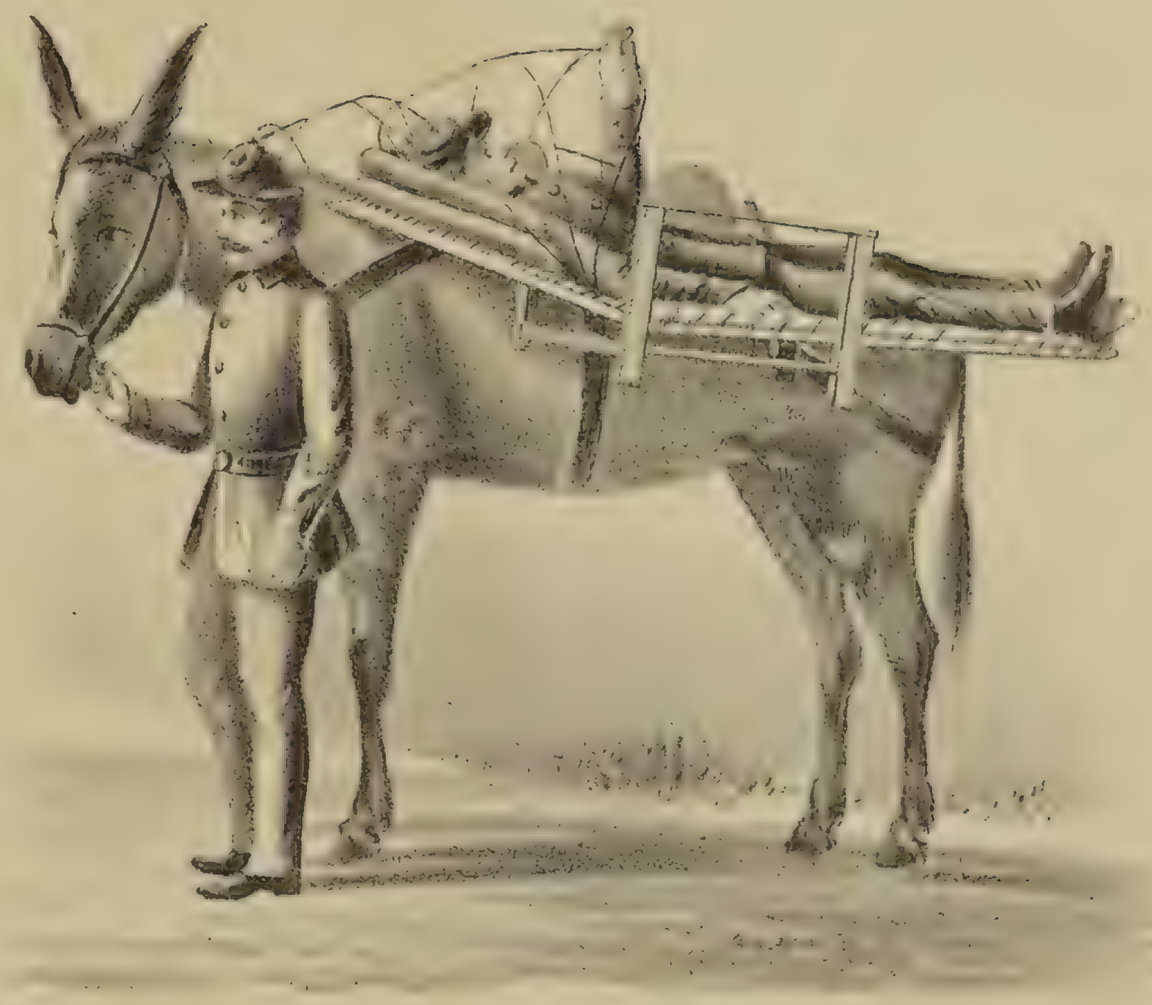
Case.—A male patient, aged thirty-five years, of spare habit, and in



1



2



3

Surgeon General's Office

Julius Bien & Co Lith

War Department.

PRIMARY TREATMENT OF INJURIES.

TRANSPORT OF WOUNDED.

Fig. 1. Two horse-litter used as hand litter (vide Fig 3 Plate IX.). Fig 2. Crimean Cacolet (Wier). Fig 3. Horse litter.

feeble health, was admitted to the ophthalmic department of the State Hospital, Ward's Island, for amaurosis. He was entirely blind in both eyes, not being able to distinguish light from darkness in open day. His face presented a vacant stare, the pupils dilated and irresponsive to light, and the globes of the eyes apparently immovable. He walked with the unsteady gait of the blind, and had somewhat lost the power of locomotion. The internal humors of the eyes were translucent; the retinæ appeared pale, anæmic, and somewhat puckered.

This patient contracted a typhoid fever, to which he succumbed three weeks after the attack, and thus afforded an opportunity for a *post-mortem* examination. The brain, with the exception of being somewhat paler than natural, presented nothing specially abnormal until reaching the region of the tubercula quadrigemina. A bundle of hydatids, two of them as large as good-sized peas, with several others of smaller proportions, was to be seen directly over and implanted upon these organs. The tubercula quadrigemina were slightly atrophied, and the process of *ramollissement* had begun. The optic tracts, chiasma, and optic nerves were abnormally white, shrunken, and cord-like, and the retinæ paler than natural, and somewhat atrophied. The diagnosis had decided the amaurosis to have originated from cerebral disturbance, and suitable treatment had been observed, without any beneficial result.

Another case of similar import to that just related is recorded by Jobert de Lamballe.

Case.—Chez un malade, la vue baissa graduellement, les pupilles se dilatèrent, et il n'y eut plus perception que d'une faible lueur. C'est par l'œil *droit* que la perte de la vue commença, et bientôt l'œil gauche cessa de voir à son tour. L'autopsie fit découvrir une tumeur comprimant les tubercules quadrijumeaux: mais la *paire gauche* avait plus souffert de la compression que la droite; aussi l'atrophie était-elle plus marquée chez la première.

Analogous cases to this are also cited by M. Magendie.

When a shock has been received, especially when resulting from direct injury of the head, the function of vision is often perturbated, or entirely

annulled for the time being. There may also be loss of vision where shock results from severe injury to other parts. When the head has been the seat of a blow, either by direct force or from *contre-coup*, the tubercula quadrigemina become directly affected, while other parts of the cerebrum act more or less normally. Where the vision becomes affected during the collapse following shock from more remote injuries, functional imperfection of vision is likely to occur from the participation of the tubercula quadrigemina in the general disturbance of the entire nervous system. The prize-fighter will tell you that in the ring, after receiving a severe blow on the forehead, though retaining consciousness, he becomes instantly blind, but only for a few moments; while the victim of a crushed limb from a railway accident slowly loses his vision during the progress and extension of the collapse, and is longer in regaining it.

The Optic Thalami.—In tracing the effects of the transmission of shock resulting from severe injuries, the anatomical relations of the large basal ganglions—the tubercula quadrigemina, the optic thalami, the corpora striata—and the continuity of the nervous fibres passing to them from the medulla oblongata, the pons Varolii, and the cerebellar and cerebral peduncles, to be distributed among the cellules of their gray substance, should be known, on account of the controlling influence which these ganglionic masses exert over the general cerebro-spinal system. A set of fibres, apparently apart from those continuous with the medulla spinalis, emanate from the anterior part of the cerebellum, and coursing along the inner and upper part of the cerebral peduncle, pass onward, and terminate, some in the tubercula quadrigemina, and some—the greater part—in the optic thalami, among the gray cellules of the red nucleus of Stilling. A direct line of communication is thus effected between the cerebellum and the optic thalami, bringing in correlation the gray matter of the corpus dentatum of the cerebellum with the gray matter of the cerebrum in the optic thalami. This combination, in instances of severe shock, tends to promote the extension or radiation of the initiatory impression, and to the more complete development of universal collapse.

The *optic thalami*, in close relation to the tubercula quadrigemina,

exercise an important influence over the function of vision, as well as over that of general sensibility. Some physiologists locate in their structure also the nervous centres of olfaction and of audition. When symptoms of persistent functional derangement of their organization continue unabated during the collapse following upon shock from violent lesions or from emotional perturbations, unfavorable results are to be apprehended. The anatomical relations of the optic thalami are necessarily complex, each one receiving the nervous fibres of the superior cerebellar peduncle, the continuation of the fibres of the upper stage of the cerebral peduncle, some fibres of the *tænia semicircularis* of Haller, and the extension of fibres in communication with the olfactory and auditory nerves. Direct communication with each other takes place also by means of the posterior and middle commissures. They consist of two ganglionic enlargements of gray nervous substance, of oval shape, and about the size of a pigeon's egg, situated over the cerebral peduncles, some of the fibres of which pass into their structure at their posterior and inferior part. Their direction is from before backward and from within outward, and by their external half they contribute, in part, to form the floor of the lateral ventricles. The superior surface is convex, and its internal half is covered by the choroid membrane and the choroid plexus. Anteriorly on this surface a whitish elevation is seen—the *anterior tubercle* of the optic thalamus—in which the anterior fibres of the anterior pillar of the fornix become lost. The *inferior* surface of the optic thalamus, in the greater part of its extent, is adherent to the upper surface of the cerebral peduncle, from which it derives a large part of the fibres of the upper or sensitive stage of the peduncle. Upon this *lower* surface, a portion of which extends beyond the cerebral peduncle, the *corpora geniculata* can be seen by separating and carrying outward the circumvolution of the *hippocampus major*. The *internal surface* of the optic thalamus in its two anterior thirds forms the wall of the middle or third ventricle, while the posterior third is in relation with the tubercula quadrigemina, and receives the fibres of the superior cerebellar peduncle. Along the upper and inner border of this surface the anterior *crura* of the pineal gland course, and passing forward, contribute, with the anterior extremities of each optic thalamus, to form the *foramen* of Munro. The

commissura mollis is met with anterior to the centre of the internal surface; farther forward the anterior pillars of the fornix can be traced penetrating into the substance of each optic thalamus, and taking a downward direction toward the mammillary eminences at the base of the brain. The *posterior commissure*, situated in front of the *tubercula quadrigemina*, below the pineal gland, is also met with on the *internal surface*. It is formed of a fasciculus of white transverse fibres, the extremities of which pass into the optic thalami, terminating there, and forming a bond of intercommunication. Below the inferior margin of this commissure, the *anus* or anterior orifice of the fissure of Sylvius is seen leading into the middle or third cerebral ventricle. The *external surface* of each optic thalamus is confounded with the corresponding *corpus striatum*, the nervous fibres and cells of which are, to a great extent, united to those of the optic thalamus.

The *anterior extremity* of the optic thalamus is separated from that of the opposite side by an interval of about two millimetres in extent. This space is placed behind the concavity of the descending pillars of the fornix, and contributes to form the *foramen* of Munro. The anterior peduncles of the pineal gland, in passing downward into the anterior pillars of the fornix below the foramen of Munro, form longitudinal fibres of communication.

The *posterior extremity* is larger than the anterior, and is separated from that of the opposite side by the tubercula quadrigemina. It is perfectly smooth, and presents on its inferior part the two *corpora geniculata*. It is surrounded by the sphenoidal prolongation of the *fissure* of Bichat. The superior wall of this fissure is here formed by the *corpora geniculata*, the *tractus opticus*, and the inferior surface of the cerebral peduncle, while the inferior wall is constituted by the *cornu Ammonis*, the *corps bordé*, and the *corps godronné*, which also form fibres of transmission. The *corpora geniculata* are two small bodies situated on the posterior and inferior part of the optic thalamus. They are slightly curved, the concavity looking inward and forward, and from each a bundle of fibres advances to assist in forming the *tractus opticus*. This nervous band passes over and adheres to the cerebral peduncle, and uniting with that of the opposite side, forms the optic commissure, or *chiasma*, from which directly emanate the optic nerves terminating

in the retina. From the posterior part of the geniculate bodies two bundles of nervous fibres pass to join the tubercula quadrigemina—one, from the *corpus geniculatum externum*, extends to the anterior tubercle; the other, from the *corpus geniculatum internum*, to the posterior tubercle.

It results from this anatomical disposition that the apparatus of vision, composed of the tubercula quadrigemina, the corpora geniculata, the tractus opticus, the chiasma, and the optic nerves, must necessarily be disturbed when shock affects a part or the whole of these continuous structures.

The *commissura mollis* and *posterior commissure* pass from one side to the other of the inner aspect of the optic thalami. The *commissura mollis* is composed of gray nervous matter, is easily broken down, and seems to be of little importance, as frequently it is not present. The *posterior commissure* is composed of white nervous fibres, the two extremities of which pass into the optic thalami, and terminate there. These structures serve as bands of communication between the optic thalami. Below the posterior commissure, the *anus* or anterior orifice of the aqueduct of Sylvius, the *iter a tertio ad quartum ventriculum*, is met with.

Structure.—The internal structure of the optic thalami indicates that they are a link in the important chain of nervous strands and ganglions that prolong the columns of the medulla spinalis toward the cerebral convolutions. The nervous cellules are disseminated through the general substance of the optic thalami; but two principal groups exist—one situated at the internal and posterior part, the red nucleus of Stilling; the other toward the centre, called the *median centre*. The red nucleus of Stilling receives the entire fibres of the superior cerebellar peduncles, while the median centre receives the greater part of the sensitive bundle of fibres from the cerebral peduncles. Thus nearly all the fibres of the *superior stage* of the cerebral peduncle are lost in the internal and inferior portion of the optic thalamus. Some physiologists have located other centres or groups of cells in the substance of the optic thalami, which are said to communicate with the nerves of special sensation, viz.: one with the olfactory nerve through the tænia semicircularis of Haller; an optic centre communicating by a small bundle of fibres with the corpora geniculata; and an auditory centre at which some fibres from

the origin of the auditory nerves terminate. Such communication by fibres of connection, if present, would affect the functional action of the organs of special sense in certain pathological conditions of the optic thalami. While such anatomical arrangement may be in doubt, it is generally accepted that most of the sensitive fibres that pass upward from the medulla spinalis, the medulla oblongata, and the *pons Varolii*, as well as the fibres which come from the superior cerebellar peduncle, terminate in the internal structure of the optic thalami, and that functional disturbance or organic lesion of these organs will exercise important influence over general sensibility. Meynert attributes to the optic thalami the province of transmitting to the corpora striata the unconscious impressions received by them, inciting thereby certain muscular movements by reflex action. There is also probably exerted in shock an important pathological influence over the coördination of muscular movement by means of the communication between the cerebellum and the optic thalami through the superior cerebellar peduncles. While the functions here attributed to the optic thalami serve to elucidate some of the phenomena that follow upon shock from external injuries, a correlation supposed to exist between these ganglia and the corresponding cortical centres located in the hemispherical convolutions requires, among other functional complexities in connection with them, farther physiological and pathological research.

A case recently came under my observation, where an autopsy was afforded, in which lesion of the optic thalamus of the left side was accompanied by diminution of sensibility of the right side. This patient had several paralytic strokes, mainly affecting the right side, the first two followed by partial recovery, but the third leaving permanent results. The most severe attack, which took place about seven months after the first, was attended by diminished sensation and complete loss of motion on the *right* side. In the progress of the malady, during the last eighteen months of his life, he suffered from loss of vision and hemi-anæsthesia of the *left* side. The external part of the *right* optic thalamus, on post-mortem examination, was found softened. This case will be further noticed when the functional disturbances of the corpora striata are under consideration.

Corpora Striata.—Upon removing the corpus callosum, the septum lucidum, the cerebral trigone, the choroid membrane, and the choroid plexus, the *corpora striata* are brought into view at the anterior part of the lateral ventricles, placed along the anterior and external portion of the optic thalami. They form the largest of the basal ganglionic masses, are composed mainly of gray substance, and influence many of the functions of voluntary and reflex motion. Posteriorly and internally they are in relation with the optic thalami, and anteriorly with the mass of white nervous fibres underlying the hemispherical cerebral convolutions and entering into the formation of the *corona radians* of Reil. The corpora striata are in close proximity at their anterior and internal part, and are brought into direct communication by the anterior cerebral commissure, which passes transversely to terminate in the substance of each. Toward the middle they are separated by the septum lucidum, and in front are overlapped by the concavity of the knee of the corpus callosum. The upper surface, which is smooth, and lies in the lateral ventricle, presents a large mass of gray substance, caudate in shape, or likened to a comma, the curve of which embraces the optic thalami, while the lower and outer boundary of each is contiguous to the *external capsule.* The corpus striatum on each side is composed of the caudate nucleus, the internal capsule, and the lenticular nucleus.

In examining the internal structure of the corpus striatum, passing from above downward, on the surface of the ventricle a gray mass, the caudate nucleus, is first met with. Upon removal of the gray substance of the caudate nucleus a layer of white substance is seen—the *internal capsule.* Most of the fibres of the internal capsule do not extend forward the entire length of the corpus striatum, the gray substance of the lenticular nucleus, situated outside of the internal capsule, passing in front, to become merged anteriorly in the gray substance of the caudate nucleus. By scraping off with the handle of a scalpel the internal capsule, and removing also the lenticular nucleus, another layer of white substance beyond the limit of the corpus striatum is brought into view—the *external capsule* of Burdach. The corpus striatum is thus in close relation inferiorly and externally with the

external capsule, the *partition*, or *avant-mur*, and the convolutions forming the *lobule* of the corpus striatum, or the island of Reil.

Internal Capsule.—The *internal capsule*, heretofore noticed as forming an important boundary between curable and incurable lesions of the cerebrum occurring from sanguineous effusion or softening of structure, is the prolongation of the fibres of the inferior or motor stage of the cerebral peduncle, assuming the form of a white lamina or band placed outside and external to the caudate nucleus and optic thalamus, and passing from behind forward in a diverging direction between the caudate and lenticular nuclei of the corpus striatum. Posteriorly the *internal capsule* extends somewhat behind the limits of the caudate nucleus; anteriorly the greater number of the fibres are distributed and are lost among the gray substance of the caudate and lenticular ganglia, while other fibres pass onward, without communicating with the ganglionic cells, toward the cortical substance of the cerebral convolutions. The posterior third of the internal capsule receives fibres that are sensitive, described by Meynert as emanating from the superior stage, and coursing along the external border of the inferior stage of the cerebral peduncle as far as the posterior limit of the optic thalamus, curve backward to terminate in the horn of the occipital lobe. The *internal capsule* thus presents two regions: the two anterior thirds, or lenticulo-striata—motor; and the posterior third, or lenticulo-optic—sensitive.

The caudate and lenticular nuclei may be regarded as sources or generators of nervous power acting in correlation with the internal capsule.

External Capsule.—The *external capsule* forms the external boundary of the aggregate mass of the *corpus striatum*. Coming from the optic thalamus, it presents a band of white fibres coursing along the margin of the lenticular nucleus, with concavity turned upward, but not adherent or incorporated with it, and advancing forward and outward, contributes fibres to the white structure of the *corona radians*.

Partition, or Avant-Mur.—Below and external to the *external capsule* a narrow strip of gray substance is met with—the *avant-mur* of Burdach. At each extremity it merges into the island of Reil, of which it seems to form a part.

Functions of the Optic Thalami and of the Corpora Striata.—The connections of the *optic thalami* with the optic chiasma through the corpora geniculata indicate an association of the optic thalami with the function of vision, while the distribution of fibres coming from the sensory strands of the medulla spinalis among the gray substance of the optic thalami connects them with the functions of general sensibility. The prolongation of fibres from the cerebellum to terminate among the cells of the *red nucleus* of Stilling would indicate that the influence or function of co-ordination attributed to the cerebellum was exercised in some degree by the optic thalami. Other connections with centres of special sense are not sufficiently verified. The optic thalami, therefore, according to physiological anatomy, are to be considered as being a ganglionic centre related to general and special sensibility. On the other hand, the *corpora striata*, anatomically considered, are judged to have a part in the performance of the motor functions. The emanation of many of the terminal fibres from the anterior motor columns of the medulla spinalis and their prolongation through the *pons Varolii* and along the *lower stage* of the cerebral peduncle to form the internal capsule, as well as pathological observations deduced from lesions of the two anterior thirds of the *internal capsule*, confirm this opinion.

The following case, the history of which dates back during its progress as far as twenty years, commenced with cerebral sanguineous effusion, accompanied by an apoplectic seizure, and terminated by abdominal dropsy and cirrhosis of the liver. The autopsy confirmed in a very positive manner the connection that existed between the cerebral lesions and the symptoms following the several attacks, taking place at short intervals, at the beginning of the disease. The injury found to have been inflicted upon the deep-seated portions of the cerebrum in proximity to and in the structure of the basal ganglions indicated severe shock at the time of its occurrence.

Case.—The patient, A—— F——, merchant, æt. 50, originally of good constitution, of superior intelligence, sanguineo-nervous temperament, and of exceedingly sensitive disposition, after a prolonged period of bad health, the principal feature of which was a hemiplegic condition of the right side, called me in consultation for the first time about two years previous to his decease.

The history of the case up to that time was related to me by a member of his family, as follows: On August 1, 1862, at the age of thirty-two, while laboring under great mental depression and agitation, and under the strain of anticipated commercial disaster, he was suddenly seized about mid-day with an apoplectic attack, and was discovered in his library lying prostrate upon a sofa, completely insensible, breathing stertorously, and showing the other signs of cerebral sanguineous effusion. A physician was hurriedly called. The patient was carried up one flight of stairs to bed, and received proper medical attention. In twenty-four hours he showed signs of improvement, and by the following Sunday had so far recuperated as to sit up in bed and read the morning papers. During the night (about 2 A.M.) he was again taken very ill, losing his speech and the power of locomotion. In about a week after this attack he regained in a great degree his speech, and began slowly to recover somewhat the power of walking. In September, under advice, he went to the country, and continued to improve, gaining strength. This favorable turn in his condition was but of short duration; for in February, some five months after the second attack, he experienced another severe paralytic stroke, falling suddenly while at the breakfast table to the floor, insensible, speechless, and unable to move, with other symptoms so grave that his family supposed he was dying. He continued without much change in this helpless condition for about two weeks. He then commenced to show signs of returning intelligence, and after a time regained very slight locomotive power. His right side remained paralytic, the right arm useless, and in efforts to walk, the right leg was put in motion mainly by being dragged. He was never able to assist in dressing himself after the last attack, and alluded to the paralytic side as his "dead side." Speech remained thick and indistinct.

The above statement contains the main features of this patient's history from the inception of his malady up to the time—a period of about eighteen years—when I was first called to see him. Notwithstanding the prolonged duration of the hemiplegia, the anterior part of the brain, after the immediate rude effects of the effusion had subsided, continued to act normally, and although otherwise helpless in a great degree, he directed

his private affairs and household arrangements with discretion and good judgment.

The muscles of the face supplied by the *portio dura*, and of the orbit by the third pair or *motores oculorum*, showed no signs of morbid action. The organs of special sense manifested no impairment of function until the last year of his illness, when vision became defective, indicating extension of the cerebral lesion, and articulation was so difficult as to render speech barely intelligible. At this period the *left* side became affected by loss of sensation.

After the acute symptoms of the attack alluded to had subsided the patient fell into a passive state, hemiplegia of the right side being confirmed, and medical treatment of little use. He was well nursed, received every hygienic attention, and his general health was good. He was in the habit of spending the summers at his country-seat to avoid the heat of the city, and returning to town at the beginning of winter. In the autumn of 1880 he became worse, and I was then requested to visit him. At this time the hemiplegia was very complete, the right leg dragging helplessly in any attempt at locomotion, and the right arm hanging lifelessly by the side, with some contraction of the wrist and fingers. Sensation also on this side was much impaired. Under the influence of tonics—quinine, nux vomica, phosphorus, etc.—administered in small doses, slight improvement took place. He continued to be interested in daily affairs, read the newspapers, and supervised some building operations. About twelve months prior to his death general sensibility on both sides became still more diminished, and on the *left* side to the extent of losing almost entirely the sensation of touch. Vision also became so impaired as to prevent his reading the daily papers, which, being one of the few pastimes still left to him, caused him to become greatly disheartened and despondent. A slight improvement afterward took place in the eyesight, and also in the tactile perceptions of the *left* side, but neither was restored to its condition prior to the relapse. In the early part of 1882 a sharp attack of jaundice came on, with tenderness over the hepatic region. This was followed by induration of the liver, œdema of the limbs, and abdominal dropsy, which required the operation of paracentesis to relieve the distress resulting from distension and difficulty of respiration. The

patient continued to grow weaker, and gradually sank under the various complications from which he had suffered, dying in August of the same year, about twenty years after the first paralytic stroke.

The immediate cause of death in this case was cirrhosis of the liver and its sequent abdominal dropsy. The diagnosis I had given during life attributed the primary disease—the apoplectic seizures, accompanied by hemiplegia, and subsequently complicated with partial anæsthesia—to sanguineous effusion in the region of the corpus striatum of the left side, followed by softening of the structure of the corpus striatum, this invading the *internal capsule*, and extending to parts of the optic thalamus of the same side.

The loss of sensation and the diminution of motor power on the *left* side and the defect of vision can be accounted for by the diseased condition of the lenticular portion of the corpus striatum, of part of the optic thalamus of the *right* side, and of the posterior portion of the internal capsule, occurring during the progress of the malady, and which the autopsy revealed.

Autopsy.—The brain was placed on a marble slab, the base downward. With a fine cerebrum knife the left hemisphere was cut horizontally so as to expose the *centrum ovale* of Vieussens; another section, about four millimetres deeper on the hemisphere, was then made in the same direction, immediately over the roof of the lateral ventricle. The lateral ventricle was now laid open by inserting the handle of a scalpel along the internal margin and breaking down the roof of the ventricle as far as the interior and posterior cornua, and pushing externally to one side the white substance overlying the ventricle. The upper surface of the corpus striatum, the optic thalamus, the choroid plexus, velum interpositum, and other parts of the ventricle were thus exposed. The two last-mentioned structures being removed, the upper surfaces of the corpus striatum and of the optic thalamus were fully brought into view, and presented the smooth, normal appearance common to the lining membrane of the ventricle. A section was next made by passing the knife vertically and transversely across the frontal lobe immediately in front of the anterior extremity of the *corpus striatum*. This section was joined by another carried longitudinally and vertically backward near and parallel to the great *median fissure*, thus detaching a somewhat

triangular portion of the frontal lobe, and exposing the structure of the anterior extremity of the corpus striatum and of the indentations in front of the convolutions of the *island* of Reil. On the surface thus presented nothing abnormal was seen. Another transverse section, parallel to the previous one, and about five millimetres posterior to it, was made through the corpus striatum and the other tissues immediately below it. The face of this section showed the fibres of the *internal capsule* located between the gray substance of the caudate and lenticular ganglions to be in a diseased condition. The lenticular portion presented a small cavity surrounded with yellow, softened structure encroaching upon the medullary fibres of the internal capsule. A third section was now made, about three millimetres behind the second, parallel to it, and a little in front of the line of depression that exists between the corpus striatum and the optic thalamus. This section opened up the middle part of the corpus striatum, in which was found a cavity, when held apart, large enough to contain a small bean, and the walls of which, to the extent of several millimetres, were surrounded by a pultaceous creamy substance which here invaded and destroyed the fibres of the internal capsule. The internal surface of this cavity was in part rough, congested, and of dark purple color. It extended a short distance into the anterior and external side of the optic thalamus, and was there also surrounded for a space of some millimetres by softened cerebral substance. A fourth transverse and vertical section was made, through the *anterior* third of the optic thalamus. This showed the termination of the cavity and softened substance mentioned as existing in the corpus striatum and extending into the antero-lateral part of the optic thalamus. A fifth transverse and vertical section continued the examination across and through the *posterior* third of the optic thalamus, exposing a cavity large enough to contain a garden pea. This centre of hemorrhagic effusion was found also surrounded by softened structure. A transverse and a vertical section made on a level with the margin of the anterior tubercles (the nates) of the tubercula quadrigemina showed nothing abnormal. A transverse section made to drop vertically, as if through the parieto-occipital lobes, exposed a cavity in the white cerebral substance, nearly on a level with the centrum ovale, large enough to contain an ordinary-

sized filbert. The wall of this cavity was directed toward the cuneiform lobe, and extended superiorly in the direction of the convolutions of the quadrilateral lobe. The white structure around this cavity was soft and pultaceous to the extent of several millimetres. The remaining parts of the left cerebral hemisphere presented no deviations from the normal condition.

The *right* cerebral hemisphere was now examined by first making the ordinary transverse section of the hemisphere to expose the white substance of the centrum ovale of Vieussens. A similar section, carried some lines deeper, opened a cavity, situated about the centre of the white substance of the cerebrum, of sufficient extent to contain a large-sized hazel-nut. This cavity was somewhat triangular in shape, extended laterally and internally toward the outer side of the optic thalamus and of the corpus striatum, and externally about three centimetres and a half from the ascending parietal lobe. The perimeter of the cavity was surrounded by softened cerebral structure, invading inwardly the external wall of the lateral ventricle, the lenticular portion of the corpus striatum *external to the internal capsule*, and, to a limited extent, the posterior part of the *internal capsule*. The caudate ganglion and the anterior portions of the internal capsule were found to be unchanged. The remaining parts of the white medullary substance of the right and left hemispheres presented nothing abnormal. The gray cortical substance overlying the lobes and lobules of both hemispheres was in a perfectly healthy condition, as were also the dura mater, pia mater, and arachnoid membranes. The anfractuosities or *sulci* between the convolutions were of unusual depth, particularly in the fronto-parietal regions.

Upon a careful examination of the external and internal structure of the cerebellum, no change from the normal organization was perceptible.

The record of the morbid symptoms manifested during the progress of this case, and the lesions as exposed by the autopsy, indicated the relation existing between the locality of the diseased structure and the perversion and annihilation of function. The prominent symptoms were hemiplegia and lessened sensibility on the right side, followed by diminution of sensation and partial loss of motor power on the left side, associated with defect of speech, and later on by imperfection of vision. The intellectual and animal functions

were generally performed in a normal manner. The order of succession of the separate attacks was indicated by the position of the different seats of the diseased structure, the amount of the disintegrated tissue, and the importance and limits of the regions involved. The first attack was of short duration, its immediate effects upon the system passing away in twenty-four hours, and its source may be localized in the white substance of the occipital lobe. The cause of the second attack, which was more severe, may be referred to the lesion found in the corpus striatum, producing, by sudden effusion of blood into the lenticular portion, a paralytic condition of a more serious character than the first. The third attack, resulting from a larger effusion of blood from the track of the *apoplectic artery* of Charcot, which destroyed the internal capsule and surrounding cerebral tissue, laid the foundation of the permanent hemiplegia, and the extension of the softening and disintegration of the cerebral tissue.

The diseased condition of the lenticular ganglion of the corpus striatum and of a portion of the optic thalamus of the right side would account for the diminution of motor power and the loss of tactile sensation and of general sensation on the left side which were revealed during the latter stages of the disease.

A question may arise as to the nature and origin of the cavities mentioned as forming centres around which there existed masses of softened pulpy degeneration of the white cerebral substance. These were undoubtedly cavities resulting from sanguineous effusion, and the subsequent absorption of the clots during the progress of the disease. Although sanguineous effusions may take place from degeneration of the blood-vessels, embolism of the arteries, and other sources of morbid nutrition, yet from the history of this case it is probable that arterial pressure, brought about by emotional influences, may have been the cause of the vascular rupture and the consequent sanguineous effusion or clot, and that the pulpy degeneration of the surrounding cerebral substance resulting therefrom made permanent the paralytic seizure. It is not impossible, however, that a diseased condition of the vessels also may have been present that predisposed to their rupture.

The localization of the cerebral structures at fault in this case was

diagnosticated during life. The loss of motion on the right side was characteristic of disease of the *corpus striatum*, including part of the *internal capsule* of the left hemisphere. The anæthesia, diminished motor power on the left side, and imperfection of vision, appearing during the progress of the disease, represented the extension of the cerebral softening (*ramollissement*) of the external part of the corpus striatum of the right hemisphere and of the optic thalamus. The cavity and softening found around it in the posterior part of the left hemisphere in proximity to the *gyrus angularis* may have modified somewhat the function of vision. The cavities or shut sacs found in proximity to the softened portions of the cerebral structure were no doubt the remains of bloody clots, the fibrine having become softened and absorbed. This explanation is in accordance with the experiments and observation of the late Mr. Gulliver, of London, who proved that a shut sac could be formed by the softening and absorption of fibrine without any cell agency.

The defective articulation resulted from the *Wallerian degeneration*, met with in the medullary strands, passing backward and downward from the basal ganglions through the *medulla oblongata*, and interfering with the origin and function of the hypoglossal nerve.

The character and severity of the shock attending the different attacks, as just related, and the seat of the cavities met with, are indicated by the symptoms, as in the preceding case, and show that lesions of the corpora striata and optic thalami from traumatic cause may be expected to be grave.

Lateral Ventricles.—The influence of severe injuries in producing the relative intensity of shock and collapse upon the general system according to the locality of the part or parts affected has been traced thus far from lesions of the peripheral nerves of the cerebro-spinal system to those of the medulla spinalis, the medulla oblongata, the pons Varolii, the cerebral peduncles, and the basal ganglions. It remains to consider this relative effect of injuries mainly expended upon the component parts of the lateral ventricles, among the fibres of the corona radiata, the cerebral convolutions, the cerebellum, and the several organs of the splanchnic cavities, supplied mainly by the branches of the *grand sympathetic*. The lateral ventricles, placed in the interior portion of the cerebrum, are formed by the upper surfaces of the

corpora striata, the optic thalami, the tænia semicircularis, the choroid plexus, and the velum interpositum, with their arteries and veins. If the parts which enter into the formation of the ventricles become the seat of laceration and effusion of blood, or are severely disturbed in their molecular organization, the collapse will be grave and often fatal; and if not fatal, will be accompanied by prolonged insensibility. The motor power may not be annulled, but it is automatic and reflex in character, amounting at times to uncontrollable jactitation. It is difficult to comprehend how the deeper portions of the brain can be reached by injuries accompanied by collapse while the more superficial structures escape. The convolutions of the brain are often severely injured and lacerated while the evidences of shock and collapse are but slight; but if these symptoms are grave and persistent, the deeper parts about the lateral ventricles are probably implicated. For example, as in a case heretofore mentioned:

A lady of good constitution, aged about thirty years, was driving in the Park, when her horses became frightened and started to run. She sprang from the carriage while they were going at a rapid pace, and struck her head violently on the ground. She was picked up insensible, and removed to her home, some two miles distant. She was seen by me about an hour after the accident, and was still insensible and in severe collapse, with all the symptoms of violent concussion of the brain, accompanied by jactitation. The external parts of the cranium had been protected by a thick braid of hair, so there was no wound of the scalp or depression of the cranium. Reaction took place slowly, but the cerebral symptoms continued unabated for several days, when incoherent words were articulated and the jactitation ceased. Gradually sentences became intelligible, and after a period of three months the brain, although sluggish, slowly resumed its normal functions. In this case, besides other cerebral complications, there was in all probability laceration with slight effusion in the lateral ventricles, or grave disturbance of their component parts from the shock of the injury. The recovery of this patient prevented positive conclusions, but from a case that came under my observation a few months since, in which I made a *post-mortem*, there was evidence that the structures surrounding the lateral ven-

tricles when abnormally affected gave rise to symptoms marked by a stupor resembling the torpor of hibernating animals.

Case.—In 1883 I was called, in conjunction with Dr. Trask, of Ravenswood, to see a gentleman of middle age, editor by occupation, who had been attacked by severe hemorrhage from the stomach. From previous debility and the loss of blood he was left in a very feeble condition. Reaction took place under treatment, but he gradually went off into a lethargic condition. This merged into a state of hebetudinous torpor, without stertorous breathing or the general signs of apoplexy. He lay perfectly motionless, breathing quietly, and could be roused so as to recognize persons a short time before death. The *post-mortem* revealed an abnormal condition of the walls of the ventricles. The lateral ventricles and the third and fourth cerebral ventricles were filled with serum. From some features of this case, the source of catalepsy would seem to be at the ventricles of the brain.

Corona Radians.—The effects upon the system of shock resulting from lesion of the *corona radians* are not so severe as might be anticipated. The *corona radians* comprises the greater portion of the white substance of the cerebrum lying under and surrounded by the gray matter of the convolutions. The medullary fibres which traverse the cerebral peduncles become partly exhausted in the central ganglions, but some of these strands pass onward to arrive at the nervous cellules of the cortical substance of the cerebrum, and thus enter into the formation of the *corona radians.* Numerous other fibres, however, take their origin from the central ganglions, from the inferior and external face of the *nucleus caudatus*, from the anterior and posterior extremities of the lenticular nucleus, from the inferior face of the optic thalamus, and, with the medullary fibres transmitted directly from the cerebral peduncles through the corpus striatum, combine to form the white cerebral mass of the *corona radians.* With the exception of the external face of the lenticular ganglion, which lies in contact with the surface of the *external capsule*, the ganglionic fibres proper issue from the external and inferior surfaces of the several nervous nuclei. Escaping from the central ganglions, the medullary fibres radiate in various directions. Some diverge toward the frontal portion of the cerebrum; some pass backward toward the

occipital lobe; the majority are directed outward transversely; others pass obliquely downward and obliquely upward so as to cross at an acute angle the transverse fibres coming from the corpus callosum, thus contributing to form the principal part of the white substance of the convolutions; some fibres are supposed to traverse the corpus callosum from one hemisphere of the cerebrum to the opposite side.

From this description it will be seen that there is a large mass of white cerebral substance which occupies the space between the basal ganglions and the lateral ventricles and the under surface of the cerebral convolutions, and which is liable to be injured by the entrance of projectiles, as, for instance, in cases of gun-shot wounds, and also by concussion or laceration resulting from external injuries.

The experiments of Flourens, Longet, and other physiologists long since proved the viability of some of the lower grades of animals after the removal of the cerebrum in front of the isthmus of the brain. The records of civil practice as well as of military surgery afford examples of the absence of the severer manifestations of shock when the analogous portions of the human brain have received grave injuries. The explanation of this toleration of shock has been referred to the character of the agencies by which the cerebral lesions are caused, the lodgement of a pistol or musket bullet in the brain not being regarded as producing such intensity of results as the crushing of one of the extremities in a railroad accident. This view can readily be sustained, for it is well known that the skull has been pierced by the passage of heavy bodies clear through it, traversing the *corona radians* of the frontal and other lobes, carrying even portions of the brain with them, and yet the patient rallied immediately so far as to be able to walk a considerable distance, and ultimately to recover. A more satisfactory explanation appears to be the partial insensibility of the white substance of the corona radiata, and the absence of extensive anastomosis with the sympathetic nerve, such as exists between the cerebro-spinal nerves of the extremities and the organic nerves. It is well ascertained that the white cerebral matter of the *corona radians* is not very sensitive, and there are no large trunks from the sympathetic nerve supplying its substance, so as to bring it in

immediate relation with the organs of the large splanchnic cavities, such as the heart, lungs, stomach, liver, and kidneys, which play an important rôle in the symptomatology of shock occurring from injuries to the extremities.

In civil practice cases are often presented similar to the one already described at page 138, where, in a case of suicide, the pistol ball was found, after death, lodged in the white substance of the frontal lobe, and yet the patient, after the first stunning effect of the shot, which struck him down, got up and walked composedly for the distance of a quarter of a mile without difficulty, and was found, an hour after the receipt of the injury, with the general functions of the body acting almost normally, and free from any symptom of collapse. Military surgery supplies many illustrations of toleration of shock and mildness of collapse after severe injuries to the medullary substance of the hemispheres. From the shape of the destructive agents used in warfare, such as the bayonet, sabre, musket or rifle ball, the injury inflicted upon the brain on the battle-field is frequently of a more limited character than when caused by falls from a height or the impetus from blows given by solid and larger bodies, such as are more commonly productive of injury in civil practice. The writings of Paré, Larrey, Schmucker, Briot, etc., afford examples of injuries to the brain unaccompanied by severe manifestations of shock or collapse. Most of these cases appear, from the descriptions given, to have been localized in the *corona radians*, thus affording repeated examples of tolerance of injury occurring in this part of the cerebral hemispheres. From these and similar cases to be found elsewhere it may be learned that the white substance of the brain can be treated with the same freedom as other parts of the system, and that it is quite justifiable to endeavor to extract balls or foreign bodies from the brain when there are indications that such procedure will be successful. I quote the following cases from some of the authorities on military surgery as corroborative of the mildness of shock in lesions of the *corona radians;* although the nomenclature of the cerebral structure as there given is not so precise as that of the present day, yet the descriptions are sufficiently clear to indicate the location of the several injuries.

Case.—Ambrose Paré relates the case of Francis of Lorraine, Duke of

Guise, who was wounded before Boulogne by a lance, which struck him above the right eye, inclining toward the nose, and which entered and passed through on the other side, between the neck and the ear, with such violence that the head of the lance and the wooden shaft were broken, and remained in, and were only removed with the aid of a farrier's pincers. "Notwithstanding all this violence," says Paré, "which was not done without the rending of bones, nerves, and arteries, and other parts, my said lord, by the help of God, was cured."

Case.—The following case is quoted from Briot: "At the battle of Pultuska, in Poland, a soldier was wounded by a bayonet, which had been fixed, but was dismounted and propelled forward by a ball. The bayonet entered the right temple two inches above the orbit; it inclined backward and downward, and traversed the maxillary sinus of the opposite side, where it passed out and projected about five inches, having penetrated to the hilt. The patient and two of his comrades tried in vain to extract the instrument. The surgeon-major, M. Fardeau, repeated the same attempts on the field, but without success. A soldier who assisted thought himself stronger than the others, and seating the patient on the ground, placed one foot against his head, and with both hands disengaged and extracted the bayonet. A considerable hemorrhage followed, and the patient fainted. M. Fardeau, who believed him dead or dying, left him to attend to others of the wounded. He revived, however; the wound was dressed; and he travelled, partly on foot and partly on horseback and in wagons, to Warsaw, twenty leagues from the field of battle. Three months after, M. Fardeau saw him, perfectly cured, but with the loss of the right eye, the pupil of which was immovable and much dilated."

Case.—Hennen gives the following case, from which I quote the initial details: "D—— M——, aged twenty-seven, a soldier in the service of Bonaparte, was wounded on the 18th June, 1815. After lying three days on the field without tasting food he was taken to a village, and afterward to one of the churches of Brussels, without anything having been done for his wound. On the 30th I sent him, with many others, to the Gens d'Armerie Hôpital, and on the 4th July he was placed under my immediate care. A

musket ball had entered at the anterior portion of the squamous suture of the right temporal bone, and passing backward and downward, fractured in its course the parietal bone, and lodged in the substance of the brain. There was a considerable degree of tumefaction of the soft parts surrounding the wound, but, with the exception of a slight headache and partial deafness of the right ear, he seemed to enjoy perfect health. He slept well, his appetite was good, his belly open, his tongue clean, his skin cool, and his pulse seventy-two, of natural strength. On the morning of the 5th the wound was laid freely open, when three large and several small pieces of bone were removed, and the ball, which was found lodged in the posterior lobe of the right hemisphere of the brain, where it rests on the tentorium, was extracted without difficulty, and with small portions of the substance of the brain adhering to it." This case recovered.

The following case is cited by the same author:

Case.—"A soldier of the Eighth Regiment of Infantry was shot in the head during the late Canadian campaign. A fracture was the consequence, with a depression of not less than an inch and a half; but as no untoward symptom occurred, no operation was had recourse to. This man recovered, and went to the rear, where, at a distance of several weeks afterward, he got an attack of phrenitis from excessive drinking, and died. As the existence of the ball in the brain was strongly suspected, an inquiry was made after death, and on dissection it was found lodged in the corpus callosum."

A very curious and interesting observation of this kind is given us by Quesnay. A brigadier in the service of the French king received a musket shot above the eyebrow. He was sufficiently recovered to return to his duty in the field the ensuing year, where he died, as it was supposed, of a *coup de soleil*. On opening his head, however, the ball was found to have penetrated two fingers'-breadth into the brain, where it lodged without giving rise to any morbid symptoms.

The primary details of one more case cited by Hennen will suffice:

Case.—"Francis Wilde, first battalion Ninety-fifth Regiment, aged twenty-eight, was wounded by a musket ball in the action of the 16th June, 1815, at Quatre Bras. The ball struck the frontal bone about an inch above

the right eyebrow, and passed in a direction toward the squamose suture of the temporal bone. He walked from the field of battle to Brussels by the help of two of his comrades. He was first seen by a native surgeon, who cleaned and dilated the wound, and then sent him to the Jesuits' Hospital, where a longitudinal fracture was discovered an inch and a half long and one broad, but no depression. The fractured bone was divided into four pieces, which were easily picked away, leaving the surface of the dura mater uncovered. In dressing him on the third day fully a dessert-spoonful of the brain and some loose splinters were discharged, but he did not appear to suffer the slightest inconvenience. Indeed, after the most minute inquiries both by Staff-Surgeon Boggie and myself, we could detect no morbid symptoms, nor the smallest difference in his system from that of a man in perfect health, except that his pulse was reduced to the very extraordinary lowness of *thirty-six beats in a minute, and had been by report so low as thirty.*"*

Cerebral Convolutions.—In tracing forward the chain of nervous communication in relation to the symptomatology of shock and collapse the physiological anatomy of the cerebral convolutions next claims attention. The convolutions of the hemispheres are composed of white medullary fibres in the interior, and of gray cineritious substance on the surface. The white medullary substance is formed of nerve fibres deprived here of the sheath of Schwann, having the character of the cylinder axis, and invested by a layer of myeline. These fibres are united by neuroglia, and are supplied by a comparatively small number of vessels. The white fibres of the convolutions consist mainly of prolongations derived from the corona radiata, but present also commissural, peduncular, and arciform or uniting fibres, so termed according to their direction and the different groups of cells which they place in communication. The extremities of the nerve fibres of the white substance are embedded in the gray substance of the convolutions.

Structure of the Gray Substance, and the disposition of the Cells in the Convolutions.—The gray substance of the cerebral convolutions, like that of the other portions of the nervous centres, is composed principally of cells.

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* Hennen, *Principles of Military Surgery.* London, 1829.

These cells form homogeneous masses, as seen in the lenticular and caudate nuclei, the red nucleus of Stilling, the *locus niger*, and in the gray substance of the medulla spinalis. In the cerebral convolutions, however, the cell elements that enter into their composition are grouped in regular series, so as to form layers, visible to the naked eye upon section of a convolution.

These layers, taken collectively, vary in depth from two to four millimetres, and are formed by a considerable quantity of nerve cells disseminated among the neuroglia—the tissue which binds the nervous elements together. The gray substance of the convolutions is supplied by numerous vessels, and is traversed by nerve fibres from the white medullary substance.

Nerve Cells.—The nerve cells of the several layers assume a pyramidal form, although fusiform cells are met with in the deepest cineritious layer. All the cells have the general characteristic of sending off a number of prolongations that anastomose with each other, so as to form, through the entire extent of the gray substance, a vast net-work, which maintains intimate relations with all the nerve cells of the convolutions. The nerve cells of the convolutions, like other cells of the nervous centres, are not provided with a membranous envelope.

According to their dimensions, the pyramidal cells are divided into *small* cells, *large* cells, and *great* or *giant* cells. The *small* pyramidal cells are numerous, with an average diameter of 10 mmm. Their summit or apex is directed toward the free surface of the brain, while their base is placed toward the white substance. They give origin at their side and at their apex to prolongations that ramify and anastomose with those from the neighboring cells. These prolongations from the protoplasma of the cells are analogous to the cylinder axis. From the base of each cell another prolongation that does not ramify originates, and is supposed to penetrate the white substance forming the cylinder axis of the nerve tubes.

The *large* pyramidal cells present a greater diameter (22 mmm.) than the preceding, but offer the same general characteristics. They are supplied by prolongations on the periphery that ramify and anastomose with each other, and give origin from the base, directed toward the white substance, to a cylindrical prolongation, without branches, that penetrates into the white

substance. This basal prolongation, said to be analogous to that presented by the cells of the anterior cornua of the medulla spinalis, is described by some physiologists as being continuous with the cylinder axis of a nerve fibre of the medullary substance. Physiological research thus authorizes the supposition that this connection between the gray nerve cells and the nerve fibres exists in the entire extent of the convolutions.

The *giant* cells differ from the preceding by the greater extent of their dimensions. Their general diameter reaches to 50 mmm.; by some writers they are said to attain the size of the motor multipolar nerve cells of the anterior cornua of the medulla spinalis (100–120 mmm.). In other respects the characteristics of the giant cells are absolutely identical with the other two varieties. The giant cells are situated in the regions where the motor centres are located.

These three varieties of cells, alike except in their dimensions, present a distinct nucleus, with the great axis in the direction of the cells. Pigmentary granules are grouped around the nucleus, which give to the cells their characteristic color, and to the surrounding regions the peculiar gray color.

The *fusiform* cells are elongated in shape, and are placed parallel to the surface of the brain, differing in this respect from the pyramidal cells. From their extremities ramified prolongations are given off. They occupy principally the deepest layer of the gray substance, and have a mean diameter of about 30 mmm.

Neuroglia is a glutinous substance which forms the greater part of the cineritious matter of the convolutions, and through which the nervous and vascular elements are distributed. Some authors consider the neuroglia of the gray substance as the proliferous element from which the cells are produced, while others regard the neuroglia as a connective substance, without distinct fibres, and enclosing a considerable mass of nervous nuclei.

The *nerve fibres* that issue from the white substance of the corona radiata of Reil penetrate the gray substance singly or in fasciculi, and connect with the nerve cells that exist in the different layers of the gray substance. As soon as they pass from the white substance into the gray matter these fibres become deprived of their myeline, and are reduced to the form of a cylinder axis.

Vessels.—The gray substance is freely supplied with blood-vessels, and consequently encephalitis, inflammatory softening, and hemorrhagic effusions are met with more frequently in the gray substance of the nervous centres and convolutions than among the white medullary fibres, which are not so richly nourished by vascular supply.

Arrangement of the Elements of the Gray Substance of the Convolutions.—The gray substance of the cerebral convolutions is described as forming five distinct layers, as follows: The first layer, very thin, is marked on a vertical section of a convolution by a distinct line, and is mainly composed of neuroglia and a number of nuclei on the surface. According to Kolliker, a plane of delicate nervous filaments is seen. The second layer, equal in thickness to the preceding, is formed principally by the *small* pyramidal cells crowded against each other, and on a section designated by a narrow colored line. The third layer, equal in thickness to the first and second united, encloses a considerable number of *great* pyramidal cells, more abundant and more crowded together on the inner surface of this layer than toward the upper surface. From the disposition of the cells, it is limited by two lines, one superficial, relatively transparent, and one deep and more distinctly colored. The fourth layer resembles the first in thickness, transparency, and composition, as well as being constituted mainly of neuroglia. The fifth layer, the most profound, is equal in thickness to the third. It is in this layer that the fusiform cells with ramified prolongations, the voluminous cells of Robin, are met with. This layer is designated by a deeply colored line. The cylinder axis of the fibres of the white substance traverse successively these different layers as far as the second layer, diminishing in numbers, a great part of them being lost in the fifth and third layers. It is not to be understood that these different elements are confined to certain layers. It is well known that the neuroglia of the first and fourth layers encloses some scattered cells, also that in the other layers of nerve cells neuroglia exists, uniting them together.

The five layers of the convolutions are traversed in every direction by ramified prolongations of protoplasm, which form communications between the cells of adjoining layers and between those of the other layers, so

that the gray substance of the convolutions, as heretofore explained, may be considered as a vast net-work of nerve cells. From the base of the *great* pyramidal cells the cylindric prolongation pointed out by Koschewnikoff arises, which basal prolongation establishes a communication between the white medullary substance and the cells of the gray substance.

The Layers of the Gray Substance as met with in the different Regions.—The existence of the five layers just described may be considered as a general type appertaining to the cerebral convolutions. In the *occipital* region of the cerebrum the gray substance of the convolutions is divided into two parts by a whitish layer. In making a vertical section, this layer is shown in the form of a band, called the *ruban de Vicq d'Azyr*. This disposition is due to the small number of nerve cells in these regions and to the abundance of neuroglia. These nerve cells, though large (30 mmm.), are isolated, and their prolongations seem to be atrophied. This peculiar arrangement of cells is seen behind the external perpendicular fissure, toward the external face of the hemisphere; behind the paracentral lobe, toward the internal face; in the temporo-sphenoidal convolution, toward the inferior face. It is supposed that these regions are in relation to *sensibility*. The anterior extremity of the frontal lobe presents the same peculiarities.

In the intermediary regions, however, it is not the same. In these an important peculiarity of structure is observed. For example, in the entire extent of the ascending frontal convolution, in the superior third of the ascending parietal, in the paracentral lobule, in the point of insertion of the three frontal convolutions upon the ascending frontal, in the *pli courbé*, and in the *cornu ammonis*, a great development of the third layer is observed, in which the great pyramidal or *giant* cells are extraordinarily developed. These cells are supposed to bear a close relation to *motion*.

The gray substance of the island of Reil and of the *partition*—the *avant-mur*—is remarkable for the development of the fifth layer, containing the large cells of volition described by Robin.

This histological *résumé* of the cortical structure, drawn from modern scientific research, is a necessary preliminary to the analysis of the intricate functions of the cerebral convolutions in health and in disease. Until re-

cently physiologists have considered the gray cineritious substance of the brain as a homogeneous structure presiding exclusively over ideation and the intellectual operations, the vesicular neurine being restricted to the development of mental energy, while to the tubular white fibres the act of conduction was assigned.

It may be stated generally that severe injuries of the cortical substance, like those occurring in the cerebral white medullary structure, are not marked by such intense severity of shock and collapse as takes place from grave lesions inflicted along the superior or inferior extremities, or when the organs contained in the splanchnic cavities are extensively involved.

A further explanation of the different effects of shock according to the seat of the injury can be drawn from the anatomical arrangement just given of the nerve cells and of their anastomosing prolongations. The net-work created by the interlacing of the prolongations forms a general connection among the entire cell-work of the cerebral convolutions, while the continuity of the terminal nerve fibres with the cell prolongations places the medullary white fibres of the general nervous system in direct communication with the cells of the cineritious matter of the convolutions.

The effects of shock may be said to be in direct proportion to the violence of the original morbid impression transmitted upon a larger or smaller area of the cerebral cortical or ganglionic nerve cells, and thence reflected upon the viscera of the splanchnic cavities, mainly supplied by the nerves of organic life and by the pneumogastrics.

When a lower limb, for example, is crushed by a cannon ball or by a wheel of a railroad car, all the nerves of the limb are lacerated. From the mangled extremities of the nerves the abnormal impression is carried through the nerve trunks to the medulla spinalis, and thence to the medulla oblongata, the pons Varolii, the crura cerebri, the optic thalami, and the corpora striata, to be propagated along the strands and fibres of the *corona radialis*, to be finally conducted by the prolongations of the nerve cells to the cells of the convolutions. The impression thus conveyed imposes the irritation of a large portion of the spinal system of nerves upon a corresponding extent of the cells of one or both of the cerebral hemispheres, thus necessarily perturb-

ing a large area of nerve cells. From the nerve cells or nerve centres thus impressed the circuitous communication that takes place between different parts of the body, partly by reflex action, is accomplished, and the heart, the lungs, the stomach, and the other structures of organic life are made to participate in the general commotion, manifested by intense collapse. On the other hand, in the case where a pistol ball enters the right temporal region, passing through the external soft tissues, the osseous wall of the cranium, the membranes of the brain, the cortex of the convolutions, and lodges among the white medullary fibres of the *corona radiata*, the nerve fibres injured carry the impression to a limited number of cells only, and consequently the reflex action upon the organs of circulation, respiration, digestion, etc., is comparatively slight, and the intensity of collapse relatively less marked.

Shock and collapse following lesions of the cortex are characterized by different symptoms according to the seat and extent of the injury. Thus in injury of the regions to which sensibility is assigned, a corresponding impairment or loss of sensation will be met with; when lesion of the motor centres occurs, perturbation or paralysis of certain portions of the muscular system will take place; while if the entire cortical substance is implicated in the injury, the associated symptoms include both the sensory and muscular systems. These symptoms will be modified as reaction progresses, or remain unchanged until death ensues.

As stated above, it is generally believed by physiologists that the phenomena of the superior functions of the brain—of intelligence, of the instincts, of memory, of will, of judgment, etc.—are under the active influence of the gray cortical substance of the cerebral convolutions. The experiments of Flourens, of Longet, of Vulpian, and many others, on this subject have established this fact. Pathological research also teaches that inflammation, acute or chronic, of the gray cortical substance of the brain produces the perversion or abolition of the intellectual faculties, marked by delirium, and followed by coma. The delirium accompanying diffuse meningo-encephalitis (the general paralysis of the insane) indicates that there is lesion of the gray cortical substance.

The continuity of the several convolutions and the probable concurrence

of action among the different organs offer difficulties in the efforts to assign a special or precise limitation to each of the faculties. In the present state of science many organs or centres have at least been approximately localized, and it may fairly be stated that knowledge of the special functions of the brain is now further advanced than was a knowledge of the nervous system generally, before the comparatively recent discoveries of Sir Charles Bell, Magendie, and Longet in relation to the functions of the medulla spinalis and the roots of the spinal nerves. From this it may reasonably be anticipated that farther researches and pathological investigation will erelong unravel the uncertainty that exists concerning the location and limitation of the doubtful and unknown organs. While the various mental processes are confidently assigned to the cerebral convolutions, modern physiologists have ascribed a new order of functions also to the cerebral gray cortex, under the denomination of motor and sensory centres.

The idea of localizing a psycho-motor centre* in the gray matter of the convolutions seems to have originated with M. Bouilland, who from repeated autopsies located the seat of speech in the frontal lobe, 1825. In 1836 a physician of Montpellier (M. Dax) carried the conception farther by remarking that aphasia, or the impossibility of expressing ideas by words, generally coincided with hemiplegia of the right side, and consequently inferred that the faculty of articulate language resided in the anterior lobe of the left side. Later M. Broca limited more precisely the area of aphasia, observing that paralytics affected by the loss of articulate language presented a lesion of the posterior part of the third frontal convolution on the left side, limiting the seat of lesion to the *pli sourcilier*, which embraces the extremity of the anterior prolongation of the fissure of Sylvius.

In 1870 MM. Fritsch and Hitzig remarked that an electric current made to pass across the head from right to left produced movements in certain muscles of the eyes. Experiments were then made upon the brains of dogs and other inferior animals, with results of a similar character. In 1873 Hitzig published a memoir in which he announced that the electric excita-

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* See Note on page 340.

tion of certain regions on the surface of the brain produced contractions in certain groups of muscles connected with definite movements of the head, body, and limbs.

About the same time, this subject was pursued farther by Ferrier, of London, who made his experiments upon the brain of the monkey, as being more closely allied in configuration to the human brain. Ferrier localized the motor regions of the cerebral hemispheres, in general terms, in the convolutions about the upper portion of the fissure of Rolando, especially in the ascending frontal and ascending parietal convolutions.*

Experiments upon living animals have indicated the location of other motor centres which have not been as yet determined upon man, but several motor centres appear to have been ascertained and corroborated by pathological observations made upon the human brain. These are situated upon the ascending frontal convolution, upon the ascending parietal convolution, upon the paracentral lobule, upon the anterior extremity of the superior parietal convolution, upon the point of insertion of the first and second parietal convolutions upon the ascending frontal convolution, and, finally, upon the *pli courbé*, or *gyrus angularis*, said to preside also over the visual function. A centre of motion is placed in the superior third of the ascending frontal convolution and in the anterior half of the paracentral lobule; this centre, overlapping the fissure of Rolando, extends somewhat upon the ascending parietal convolution. Excitation here by electricity provokes movements in the anterior member of the animal, in the superior extremity of man. Another centre is placed in the superior half of the ascending parietal convolution, in the posterior half of the paracentral lobule, and in the anterior part of the superior parietal convolution. Electric excitation of this centre produces movement of the posterior member of the animal and of the inferior extremity of man.

A motor centre of much less extent than the two preceding exists upon the root of the first frontal convolution, about two centimetres anterior to the

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* Ferrier, *The Functions of the Brain.* London, 1876. Charcot, *Leçons sur les Localizations dans les Maladies du Cerveau.* Paris, 1876.

motor centre of the superior member, electric excitation of which determines movements of rotation of the head and neck. Another motor centre is found below the preceding, upon the root of the second frontal convolution at its insertion upon the ascending frontal. This centre appears to preside over the movements of the inferior muscles of the face: there is no action upon the orbicularis palpebrarum. The centre of the third frontal convolution which presides over the movements necessary to articulate language has been designated already.* The three frontal convolutions thus present each a motor centre on a level with the point where they appear to be detached from the ascending frontal lobe. The *pli courbé*, which caps the posterior extremity of the parallel fissure, contains a motor centre the electric excitation of which provokes movements of the eye. The exact limitation of these motor centres may not be established, but it will be of practical use to map these regions in the memory so far as knowledge in respect to them has advanced.

The histological character of the motor centres is nearly the same as the rest of the cerebral cortical substance, with this difference, that the motor centres, in the third layer exhibit a greater number of pyramidal giant cells.

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* The term aphasia—*a* priv. and *φημί, to speak*—has been used to designate the inability to put into action the mental combinations necessary for the production of articulate language in man. The centre of this combination is placed by physiologists in the cortex of a portion of the third frontal convolution of the left hemisphere. Although it may be taken for granted that this statement is correct, the question arises, is it probable that the gray matter alone functionates the ideas as well as the stimulus that puts into action the muscular mechanism required for articulation? An idea, once started in the cortex, supplies the stimulus which arouses into activity the motor apparatus, either through reflex action or by direct nervous continuity. Disease of the cortex, by disturbing this combination of ideation and of muscular action, will produce aphasia, because *word ideation* has ceased. In this case the patient cannot say or write what he wishes; the nerve cells do not supply the *word* or *words*. This kind of aphasia is called amnesic aphasia—*a* priv. and *μνήμη, memory;* also agraphic—*a* priv. and *γράφω, to write.*

The other form is termed ataxic aphasia—*a* priv. and *τάξις, order.* Here the patient knows the word he wants, the ideation of *words* is perfect, but he cannot speak, or even read aloud what he has written. The voluntary motor muscular action necessary for articulation fails. The patient can write his ideas, can play cards, but articulate combination, or the coördination of word ideation and muscular action, is impossible. In this case the gray matter is normal, but the other component part of the convolution, the white or medullary portion, is softened or otherwise diseased.

Where aphasia is complete—that is, where the ideation of words is defective or absent, and where, also, the requisite muscular mechanism has ceased to act—both the gray matter and the medullary substance of the convolutions are in a diseased condition. The convolution of Broca may thus be called a compound or *psycho-motor* functionating convolution.

The action of the motor centres is crossed; that is, a motor centre of the right side presides over the movements of the left side, and *vice versa*. In this respect, however, the motor centre of articulate language appears to be an exception: while the other motor centres are placed upon the two hemispheres at symmetrical points, that of articulate language seems to exist only in the third frontal convolution of the left side. The explanation of this is supposed to be that the left hemisphere, comparatively larger in the infant, by preference presides over the acts that require force and address, and the human being from habit grows up to be right-handed, and that the same instinctive preference governs the special muscular movements necessary for the articulation of words. Aphasia, however, is met with in lesion of the right third frontal convolution. M. Broca, after investigation, contended that in the left-handed a motor centre of articulate language existed in the right third frontal convolution, as shown by lesion of that organ in connection with aphasia in the left-handed, and that with them exceptionally the right hemisphere was earlier and more developed than the left.

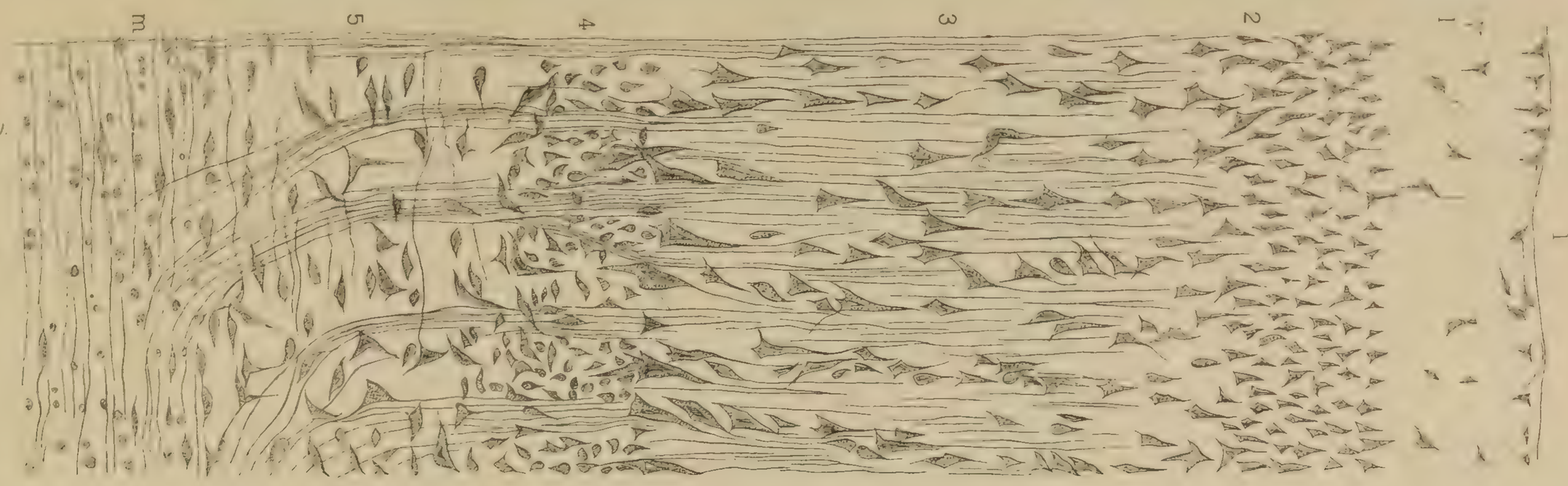
The general superficial cineritious matter of the brain is considered to be from two to four millimetres in thickness, but the limitation in depth of the white fibrous substance of the convolutions is not so precisely laid down. It is conceded that the convolutions contain the efferent and afferent fibres, and are in communication by means of the various forms of commissural, arciform, peduncular, and radiating fibres. Whether the gray matter of the motor centres alone originates the supply of nervous power and communicates it to the white medullary fibres, or whether motor excitability also resides in the cineritious cells of the convolutions, is still a question that is not definitely settled. It is acknowledged that the galvanic current, applied directly upon and on a level with the gray substance of the motor centres, produces muscular contraction, yet Carville, Duret, and other physiologists assert that if the gray substance of the motor centres is removed by a curette or destroyed by the actual cautery, the galvanic current applied upon the subjacent white substance will equally occasion the production of the same movements.

Also, paralysis produced by the destruction of a motor centre becomes cured in time although reparation shall not have taken place at the seat of the lesion. In this case the motor function might be supposed to be restored through the corresponding motor centre of the opposite side. To meet this explanation the following fact, derived from experiment, is opposed: If upon both hemispheres of an animal two corresponding motor centres be destroyed, the resulting paralysis may be cured notwithstanding the absence of reparation at the points of lesion. It is a question, then, whether the alleged double functionating power of the gray matter, of affording nervous supply and also of exercising voluntary motion, resides exclusively in the gray cineritious cells of certain convolutions, or whether the fibrous prolongations of the white substance traversing the different layers of the cineritious matter become active independently under the influence of stimulus imparted to them directly or indirectly. But be this as it may, the fact of the location of the motor centres in certain parts of the brain is established.

Notwithstanding the important control that the gray matter and white medullary substance of the convolutions exert over the general system, they are comparatively insusceptible to the sensation of physical pain. From this circumstance, and from the scanty supply of sensitive nerve branches, the explanation may be derived of the feeble manifestations of shock and collapse after traumatic lesions inflicted on the general structure of the convolutions when not complicated by profuse hemorrhage.

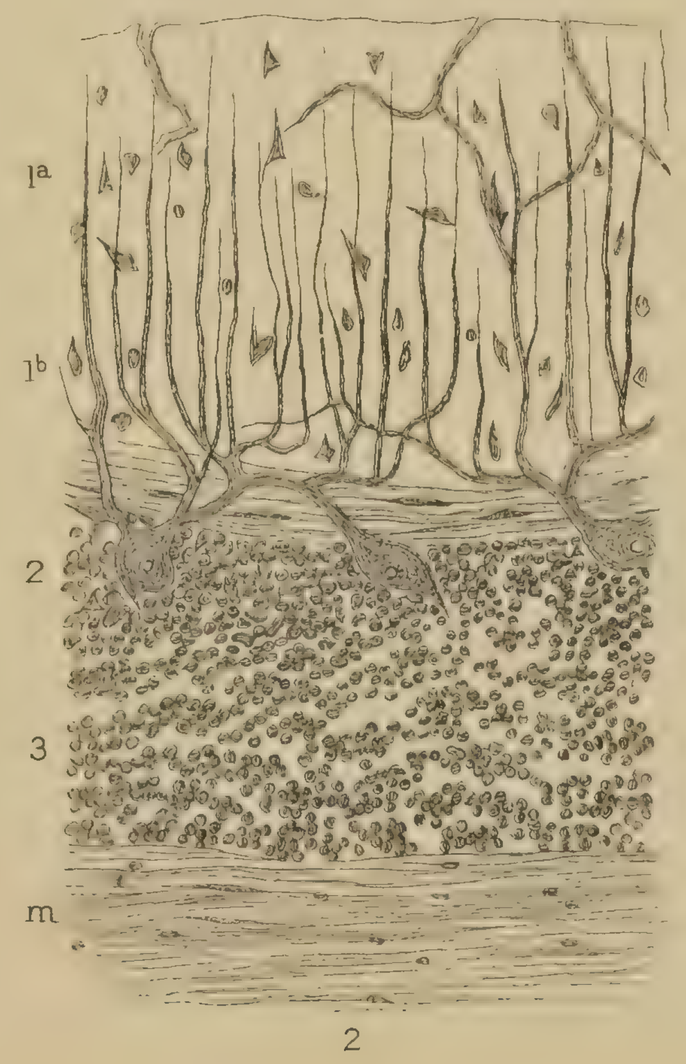
Case.—The following case is of interest as bearing upon the observations of Fritsch and Hitzig, and more particularly upon the experiments of Ferrier upon the monkey, in relation to the seat of some of the nervous centres of voluntary motion, and of the action of the cineritious matter of the convolutions.

A patient, M—— A——, twenty-five years of age, male, blacksmith by occupation, in a feeble condition, was brought into the State Emigrants' Hospital, when I was in attendance, afflicted by partial paralysis, and presenting a remarkable appearance from rigid contraction of the muscles of the face, head, and neck, and of the superior and inferior extremities on both sides. When standing he was partly twisted to one side, the head, neck,



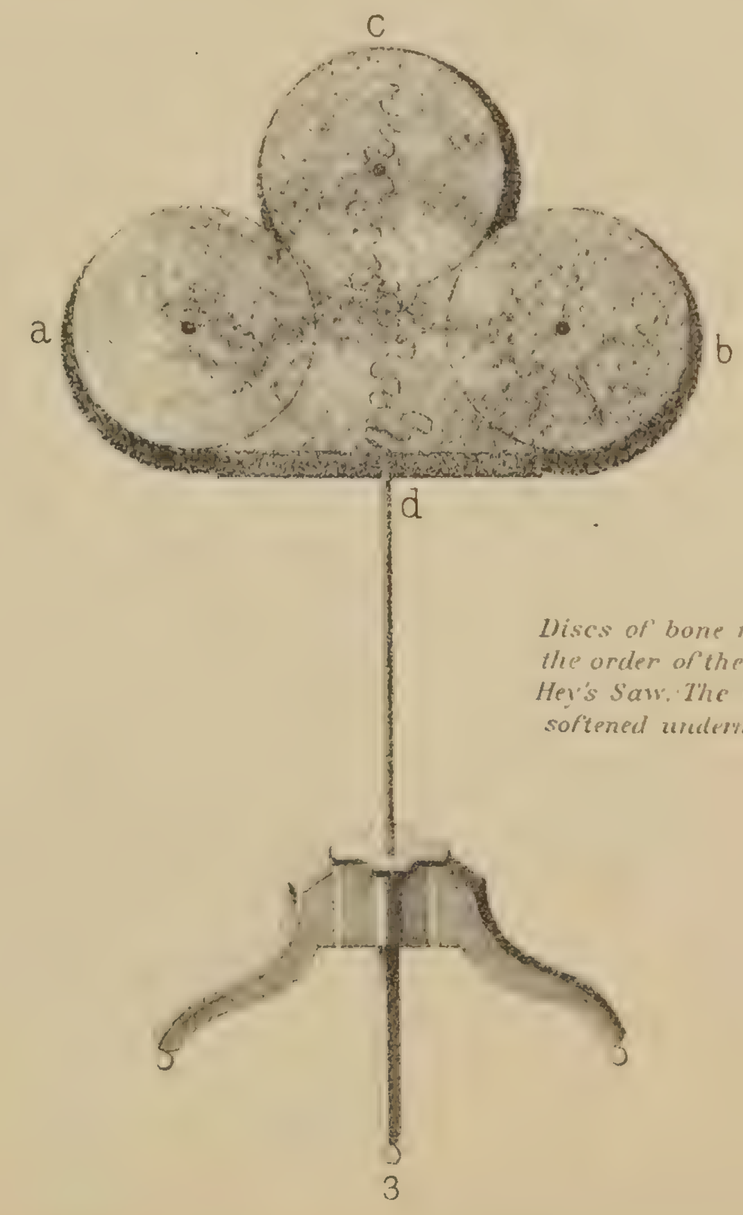
Section of the Grey Matter of the Hemisphere taken from the third Frontal Convolution (after Meynert). X 450 diam

1. Layer of scattered small cortical corpuscles. 2. Layer of close-set small pyramidal cortical corpuscles. 3. Layer of large pyramidal cortical corpuscles (Ammon's horn formation) 4 Layer of small close set irregularly shaped cortical corpuscles (granule-like formation) 5 Layer of fusiform cortical corpuscles (claustrum formation) m. Medullary lamina.



Section of the Cortex of the Cerebellum (after Meynert). X 450 diam

1.a External portion of the pure grey layer
1.b Internal portion of the pure grey layer with fusiform cells and fibræ arcuatæ
2 The Layers of Purkinje's cells.
3. The granule layers
m Medullary lamina.



Discs of bone removed by the trephine in the order of the letters a.b.c.d removed by Hey's Saw. The Cerebral substance was softened underneath the seat of depression. Case Page 342.

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FIG. 1. & 2. STRUCTURE OF GREY SUBSTANCE AND DISPOSITION OF NERVE CELLS IN THE CONVOLUTIONS OF THE CEREBRUM AND IN THE CORTEX OF CEREBELLUM.
FIG. 3. REPRESENTS DISCS OF BONE REMOVED BY TREPHINE.

Case Page 342, of osseous depression of sinciput.

and limbs inclining forward in a lateral direction toward the left side, and the lower part of the face was awry from muscular contortion. The muscles of the superior extremities were in a state of rigid contraction, bending the joints from the preponderating action of the flexor muscles. A similar condition existed among the muscles of the inferior extremities, the left limb maintaining a position in advance of the right, showing an attitude, when standing, inclining toward the left side. The gait was shuffling and unsteady. The general functions of the body were imperfectly performed; the intelligence was feeble; the motion of the eyes was not changed; articulation of words was marred and indistinct. He was conscious of his ailments, and gave some details of the history of his case, calling attention to the seat of an osseous depression on the sinciput. About a year previous to this, while at work, he had been struck by an iron bar on the upper part of the cranium. He was felled to the ground, and was removed to his home in a state of insensibility. The symptoms of concussion gradually subsided, but no intelligence was apparent for several weeks. On the subsidence of the swelling resulting from the contusion, the osseous depression on the top of the head was discovered. This received little attention, treatment being directed mainly to improve the general condition. After the immediate effects of the injury had passed off, it appeared that a large proportion of the muscular system was partially paralyzed and in a state of contractile rigidity. The patient improved so far as to enable him to walk in a dragging and unsteady manner; but his infirmity increasing, he applied for admission to the hospital. The area of the depression was somewhat larger than a silver half-dollar, and was circular in shape. It was situated about half an inch behind the middle of the coronal suture, on the mesial line, extending backward and forward and on either side of the sagittal suture, the larger portion being laterally more upon the right side of the suture than upon the left. The depression was about two lines in depth at the centre, and was bevelled off toward the margin. After several weeks of general treatment in the hospital, I performed, assisted by the surgical staff, the operation of removing by the trephine and Hey's saw several disks and portions of the bone producing the compression on the brain (*vide* Plate XI., Figs. 2 and 3).

No difficulty was encountered during the operation, with the exception of the adhesion between the under surface of the bone and the dura mater. Laceration of this membrane or injury to the longitudinal sinus was avoided by careful manipulation. The line of the sagittal suture passing through the depressed portion of bone was completely ossified. After the elevation of the bone from the surface of the brain, the symptoms became perceptibly more favorable, the rigid muscular contraction relaxed somewhat, and the painful sensation of tension and heaviness about the head previously complained of was much relieved. This favorable result was not of long duration. On the third day after the operation febrile reaction set in, followed by increased severity of the former symptoms. Delirium ensued. During the progress of the relapse the disturbance of the muscular system became aggravated, and after eight days of suffering, epileptiform convulsion and coma ended the scene.

Autopsy.—The edges of the incisions required by the operation had only partially united, and the surrounding tissues were flabby and tumid. The scalp being reflected, the calvarium was easily removed, and the surface of the dura mater exposed. At the seat of the injury where the bone had been removed the dura mater was thickened, adhering partly to the overlying tissues, and was of a reddish-gray color, with patches of purulent exudation on the surface. Upon pressure by the finger the sensation of abnormal softening differed from the fluctuation of a collection of pus. The dura mater, which had been opened on the side during the removal of the calvarium, was farther incised in a circular direction, and reflected from the surface of each cerebral hemisphere toward the great median fissure. The falx was detached from its position between the hemispheres, and removed, together with the portions of dura mater already reflected. The arachnoid, pia mater, and convolutions of the hemispheres were thus brought into view.

The cerebral structure at the seat of lesion next claimed attention. The portions of the convolutions affected were comprised chiefly within the area subjacent to the depressed cranium, namely, the anterior part of the superior parietal convolution, the upper part of the ascending parietal convolution, extending also across the upper part of the fissure of Rolando to the upper

part of the ascending frontal convolution as far as the posterior part of the superior frontal convolution, and downward along the paracentral lobule. The diseased condition passed over the median line on both sides of the great median fissure, but occupied a larger space on the right side than on the left. The arachnoid and pia mater were broken down and entangled with the softened cerebral substance of the implicated convolutions. The cortex was softened and discolored through its entire depth, and the subjacent white medullary substance was also softened to the consistence of thick cream for nearly half an inch below the level of the cortex. The remaining parts of the encephalon presented no marks of disease.

The *post-mortem* examination in this case presents features of interest in relation to the parts of the brain that became diseased in consequence of the prolonged compression of the cerebral tissue by the depressed bone. The operation was predicated upon the disturbed action of the brain and nervous system as a sequent to the abnormal pressure. The area of cerebral disease here was limited, and corresponded to the limits of portions of the brain in which, according to the experiments of Ferrier and others, particular centres of voluntary motion have been localized. This patient was treated before the experiments alluded to had taken place, but recent autopsic observations in cases of cerebral disease, as well as experiments upon animals most closely allied to man, justify the opinion that many of the voluntary motor functions are located in or about the parts of the brain affected in this case. The collapse occurring from the shock of the injury does not appear to have been severe, for, as the symptoms of the concussion subsided, reaction gradually took place, while the effects of compression remained.

The Cerebellum.—The cerebellum is that portion of the encephalic mass which fills the lower occipital fossæ. It is in juxtaposition with the pons Varolii anteriorly, and embraces inferiorly the upper part of the medulla oblongata. The upper surface is separated from the posterior lobes of the cerebrum by the tentorium cerebelli, and its circumference corresponds to the horizontal portion of the lateral sinuses. It is separated from the pons Varolii and the bulb by the fourth ventricle, and is united to the cerebrum and the medulla oblongata by three crura or cords of white medullary sub-

stance situated on each side of the fourth ventricle, known as the peduncles of the cerebellum. The external surface of the cerebellum is of a grayish color, like that of the cerebrum, and presents furrows and elevations, which, however, describe regular curves, differing in this respect from the anfractuosities of the cerebral convolutions. The elevations between the furrows constitute the plates or lamellæ of the cerebellum. The cerebellum is divided into two lobes or hemispheres, one on each side, and a median lobe. There is also a superior surface and an inferior surface. The superior surface on each side of the median line presents an inclined plane facing upward and outward, with plates and furrows describing curves concave anteriorly. In the median line the antero-posterior projection known as the superior vermiform process is seen. On the inferior surface the division of the cerebellum into two lateral hemispheres by the deep interhemispheric fissure is more obvious. By separating the margins of this fissure the projection of the inferior vermiform process is brought into view. This elevation is continuous posteriorly with the posterior extremity of the superior vermiform process, and anteriorly terminates in the cavity of the fourth ventricle by a free process or projection called the uvula. The superior and inferior vermiform processes united constitute the median lobe of the cerebellum. At their anterior extremity they are separated by the valve of Vieussens, which, by uniting the two superior cerebellar peduncles, forms the vault of the fourth ventricle. The plates or lamellæ of the vermiform processes are directed transversely, while those of the lateral lobes describe curves with concavity directed anteriorly and internally. Some of the laminæ of the inferior vermiform process cross and penetrate into the two hemispheres, and with the process itself form a transverse projection termed the pyramid of Malacarne. On each side of the uvula two laminæ of nerve substance stretching toward the lobule of the *nervus vagus* form the valves of Tarin. The lobule of the *nervus vagus* is a small rounded mass situated at the anterior part of the cerebellum, on the inferior border of the middle cerebellar peduncle, about the size of a large pea, receiving its name from the relation which it has with the roots of the *nervus vagus*. The lobule of the rachidian bulb, or the tonsil, is another rounded projection, larger than the

preceding, situated behind and on each side of the bulb. The tonsils, or amygdalæ, rest over the foramen magnum, and with the bulb, the vertebral arteries, and the roots of the two spinal accessory nerves, mainly fill up the foramen. The circumference of the cerebellum is traversed to a great extent by a furrow from a centimetre to a centimetre and a half in depth, which divides the cerebellum into halves, a superior and an inferior half. This is called the great circumferential furrow of Vicq d'Azyr. The surface of this furrow presents other furrows and laminæ. The interior formation of the cerebellum is displayed by making an antero-posterior and vertical section through the centre of the median lobe, and another in the same direction through one of the lateral lobes. The section through the median lobe shows that the central white substance of the cerebellum advances toward the gray cortical substance under the form of ramifying laminated fasciculi, that are covered by the gray substance around the points of their separation, presenting a wavy appearance—the arbor vitæ of the median lobe. A similar antero-posterior section carried through the lateral lobe will show the arbor vitæ of the lateral lobe, differing only from the preceding by the ramifications of the white substance being larger, and the relatively less proportion of the gray cineritious matter. A horizontal section made from before backward and carried parallel to the superior surface of the superior cerebellar peduncles and the valve of Vieussens exhibits in each of the lateral lobes the position of the corpus rhomboideum of the cerebellum, marked by a sinuous line of gray matter enclosing a rounded mass of white substance. This appears to penetrate the undulating line of gray matter by an opening facing the lateral angle of the fourth ventricle.

Peduncles of the Cerebellum.—Toward the lateral angles of the fourth ventricle the three cerebellar peduncles emerge from the cerebellum, diverging as they separate. The superior cerebellar peduncles advance forward and upward, to pass under the tubercula quadrigemina toward the optic thalami. The middle cerebellar peduncles pass directly forward, to mix with the fibres of the pons Varolii. The inferior cerebellar peduncles are directed downward and slightly inward, to become united with the borders or margins of the floor of the fourth ventricle.

Structure of the Cerebellum.—The cerebellum presents points of interest in relation to impressions made upon it by severe injuries, and the subsequent effects resulting from those impressions upon the general system. The connection with the cerebrum and the medulla spinalis is not so intimate as to favor the extensive radiation of shock resulting from severe uncomplicated traumatic lesions. Like the gray matter of the convolutions of the cerebrum, the cortex of the cerebellum is not sensitive to the action of ordinary mechanical or chemical irritants.

The white medullary fibres of which the greater portion of the cerebellum is composed pass but to a limited extent among the structures of the other parts of the cerebro-spinal axis. The cerebellum, like the cerebrum, is formed of white medullary fibres and of gray cineritious matter. The white fibres are derived principally from prolongations of the cerebellar peduncles passing into the general substance of the cerebellum. Some of the fibres extend from the corpus rhomboideum to the superficial cineritious matter. The superior and inferior peduncles spread out mainly into the lateral lobes, and the fibres of the middle peduncles diverge in different directions into the lateral lobes as well as into the median lobe. The existence of commissural fibres uniting the two hemispheres of the cerebellum, and of fibres of communication and association reuniting the laminæ and lamellæ of the same hemisphere, as in the cerebrum, have not been demonstrated. The neuroglia of the white substance is similar to that of the white substance of the cerebrum, with the exception that it contains a greater number of nuclei. The termination of the cerebellar peduncles outside the cerebellum indicates the limit of the connection between the cerebellum and the cerebrum. The fibres of the superior cerebellar peduncles decussate entirely between the cerebral peduncles and the tubercula quadrigemina, and terminate in the nerve cells of the *red nucleus* of Stilling, situated in the substance of the optic thalamus. The fibres of the middle cerebellar peduncle spread out anteriorly to form the superficial layer of the pons Varolii. They intercross upon the median line with those of the opposite side, and pass into the nerve cells of the gray matter situated in the substance of the pons. Other fibres of the middle peduncle of one side pass into the

peduncle of the opposite side without having relation with the nerve cells so as to form a true commissure between the cerebellar hemispheres. The fibres of the inferior cerebellar peduncle are distributed and lost in the nerve cells of the floor of the fourth ventricle, on a level with the bulb. Meynert, however, asserts that the restiform bodies, representing the inferior peduncles, are continuations of the posterior columns of the spinal cord in cross relation to each other, the restiform body on one side being in connection with the opposite posterior column. The fibres of the cerebellar peduncles thus form a particular system, terminating at three centres of cineritious cells—at the nucleus of Stilling, at the gray substance of the pons, and at the gray substance of the floor of the fourth ventricle. The continuity of the fibres of the cerebellum with those of the medulla spinalis is not admitted by some scientists, and as no fibres from the cerebellum to the cerebrum pass beyond the optic thalami, it will be seen that the principal intercommunication between the cerebellum and the rest of the nervous system takes place at the fourth ventricle, where so many of the cerebral nerves have their origin.

The Gray Substance.—The gray undulating layer of the corpus rhomboideum is the only cineritious substance met with in the interior of the cerebellum. Each surface of this body is surrounded by white medullary matter, the fibres of which are in relation with the prolongations from the nerve cells of which it is formed. The gray matter of the laminæ and lamellæ of the cerebellum is somewhat darker in color and of less consistence than that of the cerebrum. It is composed of cells and neuroglia arranged in three regularly superposed layers, viz., a deep layer formed of neuroglia, a middle layer enclosing a single range of cells, and a superficial layer containing neuroglia and the ramified prolongations of the subjacent nerve cells. The deep layer, somewhat of a rusty color, contains a large number of cells like those of the first and fourth layers of the gray substance of the cerebral convolutions. The middle layer contains a single plane of large globular cells—the cells of Purkenje—separated from each other by the neuroglia. The superficial layer contains some isolated cells and neuroglia, and the ramified prolongations from the cells of the subjacent layer;

these bifurcate and diverge in various directions, and are supposed to be continuous with the fibres of the white substance.

The cerebellum, like the cerebrum, is thus seen to be provided with the gray cellular nerve substance that acts as generator of the nervous fluid, and the white medullary fibres that take the part of conducting the impulses of voluntary motion and sensation.

The vessels of the cerebrum and of the cerebellum will be considered together.

Injuries of the Cerebellum in Relation to Shock and Collapse.—As previously stated, the physiological anatomy of the cerebellum does not indicate extended radiation over the general organism of the morbid impressions resulting from severe lesions. The connections of the cerebellum with the cerebrum, with the optic thalami, with the pons Varolii, and with the medulla spinalis are not associated with the numerous and extensive anastomoses with the grand sympathetic that are necessary to transmit with intensity impressions upon the vital organs contained in the large splanchnic cavities. The cerebellum in this respect somewhat resembles the cerebrum. The nervous mass of the encephalon is in a great degree passive under acute irritation suddenly induced, until the tracts or radicles of the cranial nerves that unite freely with the sympathetic system of nerves are reached. When this occurs the effects of shock become more marked and severe, and, according to the seat of the injury—at or near the medulla oblongata, for example—the result may prove more or less speedily fatal.

Physiologists have attributed various functions to the cerebellum. It has been at one time regarded as the general seat of sensation—the *sensorium commune;* at another, as governing in great part the movements of the body. According to Gall, it is the seat of physical love; and Signor Lussana, of Padua, has located in the cerebellum the muscular sense, or that peculiar sensibility which gives the faculty of measuring and governing the contractions necessary for the accomplishment of the various natural movements. The experiments of Flourens, and more recently of Ferrier, on the monkey sufficiently prove that the functions of the cerebrum and

cerebellum are distinct from each other, and that the cerebellum, abstractly considered, takes no part in the functions of the cerebrum. They also show that lesions of the deep parts of the cerebellum result in a remarkable disorder and irregularity of movement, and that the destruction or removal of the cerebellum destroys the coördination of the movements of locomotion and the possibility of maintaining normal equilibration. That the maintenance of equilibrium is a function of the mesencephalic and cerebellar centres is clearly demonstrated by Goltz's balancing experiments on frogs and birds.

"It has been seen that an animal deprived of its cerebral hemispheres is capable not only of maintaining its equilibrium if undisturbed, but of regaining it when overthrown. It can incline the head and body in such a manner, when the basis of support is tilted, as to keep the centre of gravity within the base. Considerable diversity and complexity of muscular movements, all adapted for this purpose, are called into play, according to the conditions under which the animal may be placed. A frog placed on an inclined plane of steep gradient is impelled as it were irresistibly to climb up in order to prevent itself falling backward. A pigeon accidentally stepping off the table into thin air is irresistibly urged to flap its wings to sustain itself until it regains *terra firma*. Mammals deprived of their cerebral hemispheres retain the same power, though to a less marked extent, the various orders of animals differing much in this respect.

"The maintenance of equilibrium is an example of æsthetico-kinesis (*αἴσθησις, the faculty of being affected by sensation; κινέω, to move—motory*), and involves the conjoint operation of three separate factors: 1. A system of afferent nerves. 2. A coördinating centre. 3. Efferent tracts in connection with the muscular apparatus concerned in the action. The faculty of equilibration is overthrown by lesion of the afferent apparatus alone, or by lesion of the encephalic centre alone, or by lesion of the efferent tracts alone, or by conjoint lesion of all. Various degrees and forms of perturbation of this function will result, according to the nature and extent and position of the lesion. In many respects the maintenance of the equilibrium resembles the tone of muscles. Lesions of the afferent nerves, central gan-

glia, or motor nerves destroy the tone of muscles; and according as this occurs in both or only in one group of analogous muscles, we have complete muscular flaccidity, or flexor or lateral distortion. So in regard to equilibrium, similar lesions may cause complete overthrow, or various forms of distortion, exhibited as reeling, staggering, rotation, and the like.

"The afferent apparatus is of a compound nature, but mainly consists of three great systems, which act in conjunction for that synæsthesis on which the due maintenance of equilibrium and coördination depend. The equilibrium is disturbed by lesions of one or more or all of these. The three systems are: 1. Organs of reception and transmission of tactile impressions. 2. Organs for the reception and transmission of visual impressions. 3. The semicircular canals of the internal ear and their afferent nerves."*

From experimental physiology and the results of accidental lesions to the human subject the conclusion is reached that the cerebellum is one of the important nerve centres upon which regulation of the movements of locomotion and the maintenance of equilibration depend, and that severe injuries inflicted upon this organ are, in addition to the symptoms of shock and collapse, likely to be associated with disturbance of the functions just mentioned, where sensibility is not entirely annihilated. The cerebellum is protected by the cervical muscles, the projection of the occipital protuberance, the tentorium above, and the spinal column below, and is less exposed to direct traumatic lesions than the cerebrum. It would be foreign to the subject in hand to enter into the arguments and controversies concerning the different theories advanced by physiologists regarding the functions of the cerebellum. Admitting the theories of Gall and of those writers who support their various opinions by pathological proofs, the influence of such chronic lesions as are brought forward by them is too remote in causation to interpret the physiological manifestations associated with shock following immediately upon injuries suddenly inflicted. The cerebrum and cerebellum are often strangely tolerant of the chronic irritations that are induced by the slow progress of morbid growths or the ischæmic softening of the en-

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* Ferrier, *The Functions of the Brain.* London, 1870.

cephalic substance, while abrupt lesions are apt to point out definitely the special physiological functions of both organs.

It may be assumed, then, that shock and collapse following injuries to the cerebellum may be associated with disturbance of the functions attributed to this part of the nervous system—such as uncontrollable jactitation and loss of the power of maintaining equilibrium—that may lead to a knowledge of the location of the injury and the prognostication of the result.

In summing up his observations on the various functions attributed to the cerebellum, M. Longet makes the following remarks, and his views are corroborated by Ferrier and other modern physiologists: "Toutefois, si, dans l'état actuel de la science, il nous était permis de donner quelque préférence à l'une des précédentes opinions, nous choisirons celle qui représente le cervelet comme influençant d'une manière spéciale la coordination des mouvements de translation, parce que la physiologie expérimentale la confirme pleinement; parce que l'anatomie anormale ne la contredit point; parce qu'enfin, comme nous avons essayé de le démontrer, elle n'est peut-être pas en opposition aussi formelle, qu'il le semblerait d'abord, avec les faits pathologiques. Rappelons que le cervelet nous a paru, comme à M. Flourens, être la seule partie de l'encéphale dont la lésion entrainât, même bien long-temps après elle, la désharmonie dans les mouvements des animaux. Cependant, nous sommes bien loin de vouloir affirmer que le cervelet ait pour rôle exclusif de coordonner les mouvements volontaires des membres, sans oser croire, avec Gall, qu'il soit la siége ou l'organe de l'instinct de la génération."

As happens with the cerebrum, injuries to the cerebellum caused by sharp-edged or pointed weapons, such as the sabre or the bayonet, are generally attended by shock and collapse of a comparatively mild character, while injuries inflicted by blunt instruments or obtuse bodies, on account of the more profound impression made by them upon the cerebellar mass, are frequently followed by dangerous collapse, aggravated by the additional complication of concussion.

The Base of the Brain and the Origin of the Cranial Nerves in Relation to Shock and Collapse.—The effects following severe injuries to the

base of the brain differ materially from those resulting from similar injuries to the upper portion of the organ. The convolutions of the superior surface and the medullary substance of the corona radiata are comparatively inert under the influence of ordinary chemical and mechanical irritants. The base of the brain, on the contrary, is, from its anatomical composition, extremely sensitive to the impressions resulting from grave lesions. The pons Varolii and the medulla oblongata, the *mésencéphale* of Chaussier, are the principal localities at which the origins of most of the cranial nerves—the nerves of common and of special sensation and of motor function—are concentrated.

The gray matter of the medulla oblongata and of the pons Varolii is a prolongation upward of that of the medulla spinalis; and in addition to this, at the floor of the fourth ventricle there is a series of special deposits or nuclei connected with the roots or real origins of all the cranial nerves, with the exception of the olfactory and the optic nerves.

At the inferior part of the medulla oblongata the arrangement of the gray matter is the same as at the superior part of the medulla spinalis, but at the fourth ventricle it becomes more abundant, and is less regularly disposed. At the floor of the fourth ventricle the portion of the gray matter corresponding to the transverse gray commissure of the cord becomes superficial and exposed by the divergence of the restiform bodies and the posterior pyramids. This brings into view several slight elevations that have received special names, so that the roots of the nerves may be more exactly localized. The lateral crescentic portions of gray matter corresponding to the posterior cornua of the cord become enlarged, and blending with the fibres of the restiform bodies, give rise to a small lateral prominence—the gray tubercle of Rolando.

The floor of the fourth ventricle, formed by the posterior surface of the medulla oblongata and a portion of the upper surface of the pons, is bounded laterally by the processus a cerebello ad testes and by the diverging posterior pyramids and the restiform bodies. It is arched over by the valve of Vieussens and the under surface of the cerebellum, where the uvula, nodulus, and amygdalæ are situated. It presents on the median line the median fissure of the calamus scriptorius, which terminates below in the

point of the calamus scriptorius. At the lowest part of this fissure is seen the orifice of a short canal, terminating in a cul-de-sac—the remains of the canal that extends in fœtal life through the centre of the medulla spinalis. At the upper extremity of the fissure, the lower orifice of the aqueduct of Sylvius is seen. The several eminences that give origin to the nerves are met with on either side of the median fissure of the calamus scriptorius. One of these, called the *locus cœruleus*, is placed a short distance from the lower orifice of the aqueduct of Sylvius. Toward the middle, and near to the fissure of the calamus, a small rounded eminence is visible, situated upon a line drawn transversely between the lateral angles of the floor of the ventricle, called the *eminentia teres*. At the inferior part of the floor of the fourth ventricle, between the fissure of the calamus and the posterior pyramid, three elongated eminences, somewhat triangular in form, are met with: the one nearest the median fissure is the internal white wing—*l'aile blanche interne ;* that nearest the posterior pyramid is termed the external white wing—*l'aile blanche externe ;* the intermediate eminence is known as the gray wing—*l'aile grise*. Each of these eminences corresponds to the origin of a nerve. Passing from above downward, the locus cœruleus corresponds to the origin of the small or motor root of the fifth pair. The eminentia teres is formed by a group of nerve cells, the common centre of the facial and the external ocular motor, or sixth pair. From the internal white wing the grand hypoglossal takes origin. The auditory springs from the external white wing. The three nerves that pass through the foramen lacerum posterius, and which emerge from the lateral furrow of the bulb, the glosso-pharyngeal, the pneumogastric, and the spinal accessory, take their origin from the intermediate or gray wing.

Bearing in mind that the gray matter of the cord is prolonged upward through the bulb and into the annular protuberance, maintaining, although in a modified form, the configuration of anterior and posterior cornua, connected by a commissural band of gray substance, will simplify the intricate tracing of the cranial nerves from their points of emergence or apparent origin through the substance of the brain to their real or deep origin. Most of the cranial nerves converge toward the annular protuberance and bulb to

reach the groups of cineritious cells of their deep origin, and become blended with the several eminences already mentioned as apparent on the surface of the floor of the fourth ventricle.

The course of the cranial nerves through the cerebral substance from the points of emergence on the base of the brain to the nerve cells that form the centres of their real origin may be briefly summarized as follows: The *third pair*, or common ocular motor, which apparently takes origin from the internal face of the cerebral peduncles, penetrates deeply into the peduncles, and passes backward and upward to reach the group of nerve cells that terminates the motor column formed by the continuation of the base of the anterior cornu, below and in front of the inferior orifice of the aqueduct of Sylvius. The *fourth pair*, the apparent origin of which seems to be at the apex of the valve of Vieussens, penetrates from above downward through the substance of the nervous structure, arriving at the lateral and superior parts of the common nucleus of the third and fourth pair, the locus cœruleus. The *fifth pair*, trifacial, presents two roots at its apparent origin upon the lateral part of the inferior face of the annular protuberance—a small motor root situated above, and a larger root, sensitive, placed more inferiorly. The smaller root penetrates from before backward and from without inward, and arrives, toward the superior part of the floor of the fourth ventricle, at a nucleus of origin situated at the superior extremity of the gray column formed by the head of the anterior cornu. The more voluminous root sinks also into the structure of the protuberance, and passes backward to finally descend obliquely in the region of the bulb and of the protuberance. The nucleus of the real origin of this root is very long, and extends from above downward upon nearly all the extent or length of the floor of the fourth ventricle, so that the fibres of the sensitive root of the trifacial become separated, as it were, to be distributed among the nerve cells of the gray substance formed by the prolongation of the posterior cornu. The *sixth pair*, oculorum motores externi, has its apparent origin at the base of the anterior pyramid of the bulb. The roots traverse the bulb from before backward, to reach a group of nerve cells occupying the middle part of the motor column formed by the base of the anterior cornu, the nerve

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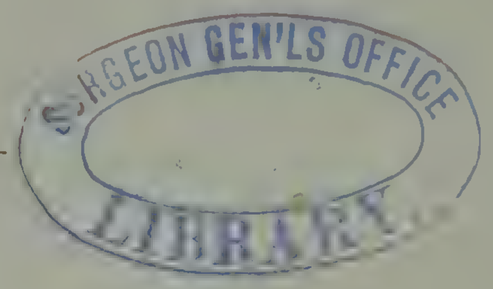
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